

## Late Cenozoic Ostracodes from the Drowned Terraces in the Hawaiian Islands

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**ABSTRACT:** Late Cenozoic ostracodes from extensive submarine terraces in the Hawaiian Islands ranging in depth from 260 to 355 fathoms resemble, in part, modern shallow water faunas of the Hawaiian and tropical Pacific islands. Of the 35 species from the terraces, 13 are described as new. These are: *Cytherelloidea monodenticulata*, *Bairdia kauaiensis*, *B. banaumaensis*, *B. ritugerda*, *Hemicythere obesa*, *Mutilus oahuensis*, *M.(?) coalescens*, *Jugosocythereis venulosus*, *Quadracythere hornibrooki*, *Loxoconcha batei*, *L. condyla*, *Cletocythereis bradyi*, and *Neocaudites terryi*.

The assemblage indicates an original shallow water environment for the terraces. Most of the extant species, which also occur as fossils from the terraces, live at depths less than 50 fathoms in present oceans, and only one is reliably reported as living deeper than 160 fathoms; several are known littoral forms.

SUBMARINE TERRACES occur at various depths on the flanks of the larger islands in the Hawaiian archipelago. The central islands of Oahu, Molokai, Lanai, Maui, and Kahoolawe surmount a common ridge which rises abruptly from the Pacific Ocean floor from 2,500 fathoms to about 300 fathoms. The conspicuous break in slope at 300 fathoms marks the outer edges of extensively developed drowned terraces (Fig. A). Submarine terraces on the north side of Kauai at about the same depth are not as extensively developed as those off the central islands. Deeper terraces are known down to 1,000 fathoms in the Hawaiian Islands (Menard et al., 1962) but have not yet been dredged.

This study is primarily concerned with the ostracode remains contained in several dredge hauls taken from the submarine terraces within the central island complex and off Kauai. While this is primarily a taxonomic study, Tables 1 and 2 are given to evaluate paleoenvironments and thus unravel the obscure history of the Hawaiian Islands. Unfortunately, such evaluation is hindered by the lack of knowledge of the precise age of the Hawaiian fossil Ostracoda

and of the ecology of living Pacific ostracodes included in this report.

Cursory observations of Recent samples from Clipperton Island and New Caledonia reveal no gross faunal similarities to the Hawaiian fossil faunas. From the limited number of Recent samples from the Hawaiian Islands it can be seen that only a few of the fossil species are presently living in that area (Table 1). Some specimens from the Recent stations are illustrated for clarity.

Marked faunistic differences occur between terraces, indicating either temporal or environmental distinctions. For example, station T-12 at 308 fathoms does not contain *Macrocypis gracilis* or *Loxoconchella honoluluensis*, which are common at stations T-1, T-4, and T-7 at 310, 280, and 297 fathoms respectively, nor does it contain the common *Mutilus* (?) *coalescens* and the abundant *Mutilus oahuensis*, found at station AR at 260 fathoms.

**BRIEF HISTORIC REVIEW OF THE OSTRACODA IN THE TROPICAL PACIFIC:** The first published work on tropical Pacific ostracodes was that of G. S. Brady (1868a) in "Fonds de la mer." However, only 1 species was treated in the central Pacific. Ostracodes from Java and Hong Kong were also covered in this series. Of greater

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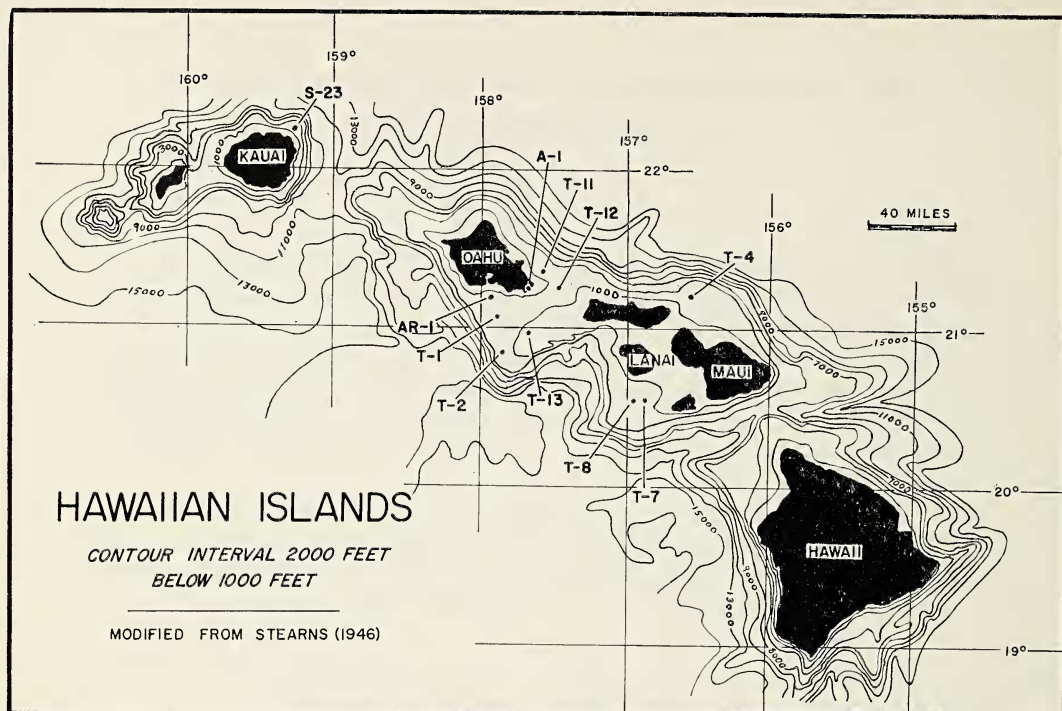


FIG. A. A bathymetric chart of the areas immediately adjacent to the Hawaiian Islands, showing a major break in slope between the 1,000- and 3,000-ft isobath. Stations HA, in Hanauma Bay, and T-13, on Penguin Bank, contain Recent ostracodes exclusively; the remaining stations contain only fossils.

import concerning Pacific faunas was the description of the Ostracoda collected during the Challenger Expedition, also by G. S. Brady, published in 1880. This was primarily a taxonomic treatment of the ostracodes obtained from dredgings in many parts of the world by the Challenger Expedition during the years 1873–1876. Though an excellent work in certain respects, and well illustrated, it was little better than a reconnaissance.

Brady again published in 1890 on the Ostracoda from some South Sea islands (New Caledonia, Samoa, and Fiji). His entire collections consisted of species found from the littoral zone to 6 fathoms. Though certainly not a comprehensive study of South Pacific ostracodes, this, together with his 1880 work, constitutes the bulk of descriptive information available on this group in the tropical Pacific.

J. Th. Kingma (1948) described 94 species, 40 of which were new, from Tertiary to Recent deposits of the Netherlands East Indies. He reported relatively few tropical Pacific island ostracodes living in the Java Sea. Shorter works

in the Indo-Pacific realm include studies of late Cenozoic fossils by Le Roy (1939, 1941) and Douglas (1931), and of Recent ostracode studies by Chapman (1902, 1910), Triebel (1954), Keij (1953, 1954), 1964), Fyan (1916), and Bold (1946b, 1950).

Major contributions have been made in the New Zealand and the South Australian regions; however, these faunas are distinct from those of the tropical Pacific region. For an historical discussion of that area the reader is referred to Hornibrook (1952). The history of ostracode study in the north Pacific–Japan area is treated thoroughly by Hanai (1959).

AGE AND PALEOECOLOGY: Menard, Allison, and Durham (1962) interpreted the age of a single station (AR of this study) to be probable Late Miocene on the basis of the ratio of extinct coral species to living species and on vagaries in shape of specimens of *Globigerinoides quadrilobatus*. The hermatypic corals indicated an initial depth of only 10 m. Allison (personal communication) has since expressed



TABLE 1

SPECIES CHECK LIST OF LATE CENOZOIC HAWAIIAN OSTRACODES FROM THE HAWAIIAN ISLANDS, CLIPPERTON ISLAND, AND EASTER ISLAND  
Relative abundances are made with reference to the total population: 0-5% rare (R); 5-15% common (C); 15-40% abundant (A); 40-100% very abundant (VA).

SPECIES	EASTER ISL.	HAWAIIAN ISLANDS												EASTER ISL.	CLIPPERTON ISL.		
		NEOGENE										RECENT					
		EA-2	T-1	T-2	T-4	T-7	T-8	T-11	T-12	AR	S-23	T-13	HA			EA-1	CL
<i>Cytherelloidea monodenticulata</i> n. sp.								R									
<i>Bairdia kauaiensis</i> n. sp.		A	VA	C	A	A	VA	A	A	A	A				C		
<i>Bairdia</i> sp.																	
<i>Bairdia hanaumaensis</i> n. sp.								R	C			R					
<i>Bairdia ritugorda</i> n. sp.		C	VA	VA			C	C	R								
<i>Bairdia attenuata</i> Brady, 1880		R				R	C	R	C	C		R					
<i>Bairdia expansa</i> Brady, 1880								R									
<i>Macracypis gracilis</i> (Brady), 1890	R	C		A	A										R		
<i>Propontocypris simplex</i> (Brady), 1880	R							R									
<i>Propontocypris</i> (?) sp.								R									
<i>Bythoceratina monstruosa</i> n. sp.	C						R	R		R							
<i>Paracytheridea</i> sp.								R									
<i>Hemicythere obesa</i> n. sp.							R	R									
<i>Hemicythere</i> sp.		R					R	R									
<i>Mutilus</i> (M.) <i>oahuensis</i> n. sp.									A								
<i>Mutilus</i> (?) <i>coalescens</i> n. sp.									C	C							
<i>Jugosocytheris venulosus</i> n. sp.							R	R									
<i>Quadracythere hornibrooki</i> n. sp.			C				R	C									
<i>Loxoconcha bati</i> n. sp.		R			C		C	R			R						
<i>Loxoconcha condyla</i> n. sp.								R			R		R				
<i>Loxoconcha longispina</i> Key, 1953		C					C	A						R			
<i>Loxoconchella honoluliensis</i> (Brady), 1880		C		C	A						R			R			
<i>Loxoconchella anomala</i> (Brady), 1880		R		C	R		C	C		R							
<i>Loxoconcha</i> sp.								R									
<i>Paradoxostoma</i> sp. A								R									
<i>Paradoxostoma</i> sp. B								R									
<i>Paradostoma</i> cf. <i>P. rubrum</i> Muller, 1894				C													
<i>Sclerochilus</i> sp. A								R									
<i>Sclerochilus</i> sp. B								R									
<i>Cleocythereis bradyi</i> n. sp.	C							R									
<i>Hermanites</i> sp.					C												
<i>Neocaudites terryi</i> n. sp.								R									
<i>Xestoleberis nana</i> Brady, 1880		C	A	A	A	VA	C	C	C	C	R	R					
<i>Anchistrocheles fumata</i> Brady, 1890								R									
" <i>Cythere</i> " <i>caudata</i> Brady, 1890		R										R					
TOTAL NUMBER OF OSTRACODES	110	32	14	15	45	7	49	493	34	35	63	350	60	87			

reservations about the age assessment due, primarily, to the occurrence of *Globorotalia truncatulinoides*. The sample from the deepest station of the present study, station S-23 from the north side of Kauai at 355 fathoms, contains many specimens of *Globorotalia truncatulinoides*, which is considered to be of Pliocene to Recent age (Geiger, 1962; Todd, 1964). Station S-23, unlike the other stations, is lithologically distinct, being composed of alternating fine beds of calcareous sand and volcanic ash; hence, the foraminifers obtained from the sand are contemporaneous with deposition. The lack of Miocene and older foraminifers also suggests that the terraces are probably no older than Pliocene. Unfortunately, a definite age cannot be assigned at present to any of the

terraces, and all must be considered here as Neogene to possibly Pleistocene, or late Cenozoic.

Ostracodes previously described and dealt with here are mostly South Pacific forms. All are found living at depths far shallower than the present depths of the terraces. Information concerning ostracodes with known depth distributions is summarized in Table 2. It is interesting to note that most have been found exclusively in water shallower than 50 fathoms. None of the Recent ostracodes from the drowned terraces are deep water forms; all occur in water less than 160 fathoms deep, with the exception of a single valve of *Bairdia attenuata* from 370 fathoms off the west coast of Africa (Egger, 1901). Unfortunately, very

TABLE 2

KNOWN DEPTH DISTRIBUTIONS IN FATHOMS OF SOME OSTRACODES FROM THE DROWNED TERRACES IN THE HAWAIIAN ISLANDS

SPECIES	PORT JACKSON, AUSTRALIA	TORRES STRAITS, AUSTRALIA	BOOBY ISLAND	"NEAR STATION 305" BRADY, 1880	NEW CALEDONIA	"STATION 167", NEW ZEALAND BRADY, 1880	FRIENDLY ISLANDS	SAMOA	FUJI	HAWAIIAN ISLANDS	CLIPPERTON ISLAND	CORONADO ISLANDS	BAY OF NAPLES	ASCENSION ISLAND	EASTER ISLAND
<i>Bairdia kauaiensis</i> n. sp.	2-10	155	6-8	160	3-6				LIT.	22-40					22-55
<i>Bairdia hanaumaensis</i> n. sp.										5, 40					
<i>Bairdia attenuata</i> Brady, 1880		155								5, 40					
<i>Bairdia expansa</i> Brady, 1880								LIT.		40					
<i>Macrocypris gracilis</i> (Brady), 1880									LIT.		20-22				
<i>Pontocypris simplex</i> (Brady), 1880														7	
<i>Bythoceratina monstrosa</i> n. sp.												5			
<i>Loxoconcha condyla</i> n. sp.										5, 22					22-55
<i>Loxoconcha longispina</i> Key, 1953					LIT.				4	22-40					22-55
<i>Loxoconchella hanoluliensis</i> (Brady), 1880					2-6			LIT.	LIT.	22-40					22-55
<i>Loxoconchella anomala</i> (Brady), 1880					3-6				LIT.	40					
<i>Paradoxostoma</i> cf. <i>P. rubrum</i> Müller, 1880													?		
<i>Cletocythereis bradyi</i> n. sp.						150				22					
<i>Xestoleberis nana</i> Brady, 1880							18			5, 22					
<i>Anchistrocheles fumata</i> Brady, 1890								LIT.							
" <i>Cythere</i> " <i>caudata</i> Brady, 1890									4	5					

little is known of the maximum depth-distributions of these living species and definite conclusions cannot be made about the initial depth of formation of the terraces. However, these assemblages do suggest shallow water environments of deposition and support an extrapolation of the paleoecological findings of Menard et al. at Station AR to the other terraces.

The apparent lack of modern sediments on the drowned terraces indicates that they are non-depositional realms, at least in part, and may have been exposed since the time of their formation. The fossil assemblages, therefore, may represent a mixture of various ages. Because of the present extreme depths this possible mixture would not be expected to contain living ostracodes, at least not of the shallow water forms treated here. The lack of well preserved speci-

mens lends support to the view that all are fossil occurrences.

In Table 2, occurrences of known and new species are reported from Easter Island, Clipperton Island, and from depths shallower than 40 fathoms in the Hawaiian Islands. The remaining stations are those of Brady (1880, 1890) and Müller (1894). Depths listed as littoral refer to "between tide marks" as used by Brady (1890).

#### ACKNOWLEDGMENTS

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Shepard of Scripps Institution of Oceanography, who collected dredge hauls from stations AR and S-23. E. C. Allison offered great assistance in many aspects of this work and contributed samples from stations HA, CL, and EA, as well as having in his charge all the dredge haul samples. Also appreciated were the helpful comments and suggestions made by E. G. Barham and E. L. Hamilton of the U. S. Navy Electronics Laboratory at San Diego, California, and N. J. Ayer, a fellow graduate student at San Diego State College. The paper has benefited greatly from discussions with W. M. Briggs, Jr., of the U. S. Geological Survey, and J. E. Hazel of the U. S. National Museum, who read and offered many helpful suggestions on the final draft. R. H. Bate of the British Museum (Natural History) kindly compared specimens of several of the species with G. S. Brady's types. Mr. Ayer, presently at the University of Illinois, proof-read the final draft.

#### DISCUSSION OF THE STATIONS

Several oceanographic expeditions have dredged the submarine terraces in the Hawaiian island chain during the past few years. The most informative sample from station AR of this paper was collected September 2, 1961 by V. W. Menard of Scripps Institution of Oceanography aboard the Scripps Institution's R. V. "Argo."

During March 26–31, 1962, thirteen dredge hauls were collected at various locations from the drowned terraces by R. D. Terry of the Autonetics Division of North American Aviation Corporation at Anaheim, California, aboard the U.S.S. "Greenlet." Of the dredge hauls obtained in this series, most of which consisted of coral fragments, eight contained rocks bearing fossil ostracodes. The dredge haul from Station T-13 of the same series was not collected from a drowned terrace but from Penguin Bank, at a depth of only 22 fathoms, and contained only Recent ostracodes.

The most recently recovered dredge haul from the area, Station S-23 of Francis P. Shepard of Scripps Institution of Oceanography, was taken aboard the Scripps Institution's R. V. "Spencer F. Baird" on September 9, 1962. Unlike the previous dredge hauls by Menard and

Terry, Shepard's was from a deeper terrace on the northeast side of the island of Kauai at 355 fathoms. This terrace is not connected with the terrace complex of the central islands but is separated by a depth of about 1,600 fathoms.

The sample from Clipperton Island (station CL) was collected by E. C. Allison and C. Limbaugh during the Scripps 1956 AGE Expedition. Material from station HA from Hanauma Bay in the Hawaiian Islands was collected by E. C. Allison in 1961. The above Recent stations are in relatively shallow water and specimens were obtained using SCUBA diving equipment.

The Recent station notations (except for Station T-13, which is part of the series collected by R. D. Terry), and including Stations CL and HA have been established by the writer. Notations AR, EA-1, and EA-2 are used here for the fossil stations established by Menard, et al. (1962) and during the Downwind expedition, respectively. In the following paragraphs the locations, bathymetry, and general physiography of each station are given together with any available information about the samples.

Station T-1. A dredge haul from 21° 9.4'N, 157° 54.6'W at 300 fathoms to 21° 7.3'N, 157° 54.4'W at 310 fathoms across the top of a terrace. A small coarse fraction was screened from light-tan coralline muds.

Station T-2. A dredge haul from 20° 51.8'N, 157° 54.7'W at 340 fathoms to 20° 52.2'N, 157° 53.6'W at 240 fathoms, up to the edge of a terrace. About 20 lb of basalt heavily encrusted with MnO<sub>2</sub>, several manganese nodules, and fossil reef material were collected.

Station T-4. A dredge haul from 21° 16.2'N, 156° 34.3'W at 280 fathoms to 21° 16.0'N, 156° 34.1'W at 278 fathoms, across the outer edge of a terrace. About 10 lb of fossil reef material were collected.

Station T-7. A dredge haul from 20° 33.3'N, 156° 54.4'W at 297 fathoms to 20° 34.9'N, 156° 52.9'W at 221 fathoms, across the top of a terrace. Total sample consisted of a quarter-pound rock specimen of calcareous algae with fossil material filling the cavities.

Station T-8. A dredge haul from 20° 34.7'N, 156° 54.5'W at 275 fathoms to 20° 34.3'N, 156° 55.8'W at 318 fathoms, across the top of

a terrace. The total sample consisted of two small rocks of calcareous algae.

Station T-11. A dredge haul from 21° 22.8'N, 157° 34.7'W at 295 fathoms to 22° 23.1'N, 157° 33.8'W at 320 fathoms across the top of a terrace. About 30 lb of reef rock, some fragments with MnO<sub>2</sub> coatings, and some basalt pebbles were collected.

Station T-12. A dredge haul from 21° 17.8'N, 157° 28.8'W at 308 fathoms to 21° 19.0'N, 157° 29.7'W at 322 fathoms across the top of a terrace. About 150 lb of reef rock similar to T-11 were collected.

Station T-13. A dredge haul from 20° 59.5'N, 157° 42.0'W at 22 fathoms to 20° 59.5'N, 157° 41.8'W at 22 fathoms, across the top of Penguin Bank. About 200 lb of living reef material were collected.

Station S-23. A dredge haul collected in September 1962 by Francis P. Shepard aboard the Scripps Institution's R. V. "Spencer F. Baird" at 22° 13.6'N, 159° 16.6'W at 355 fathoms, on a drowned terrace on the north side of Kauai.

Station HA. A bottom sample collected in August 1962 by Edwin C. Allison at 157° 41.8'W, 21° 16.5'N at 10 m in Hanauma Bay, on the southeast corner of Oahu, consisting of about 1 lb of clean calcareous sand containing living ostracodes.

Station AR. A dredge haul collected by Henry W. Menard aboard the Scripps Institute's R. V. "Argo" at about 21° 14'N, 157° 57'W at about 260 fathoms from a drowned terrace off Honolulu, Hawaii. More than 200 lb of fossil reef debris were collected.

Station CL. A bottom sample collected in August 1948 by Edwin C. Allison off the edge of a submerged terrace on the north side of Clipperton Island, opposite the west end of the main washout area, at 20–22 fathoms. Sample contained living ostracodes.

Station EA-1. A dredge haul collected in February 1958 during the Scripps Institute of Oceanography's Downwind Expedition at 27° 04'S, 109° 18'W at 22–25 fathoms in La Perouse Bay, Easter Island. The sample contained 200 lb of basalt cobbles and calcareous debris and living coral.

Station EA-2. A dredge haul collected in February 1958 during the Scripps Institute of

Oceanography's Downwind Expedition at 27° 04'S, 109° 16'W at 72–80 fathoms. The sample contained 50 lb of living corals and mollusks around fossiliferous limestone and marl.

#### SYSTEMATIC DESCRIPTIONS

Following each locality number in the species-distribution section is the absolute abundance of that species; the number of single valves observed is denoted by "valves," entire specimens by "entire." All measurements are in millimeters.

Most of the types are deposited at the U. S. National Museum in Washington, D.C. and are designated with USNM numbers. Some secondary types are deposited at the San Diego Museum of Natural History in San Diego, California, and are designated with SDNH numbers (San Diego Natural History Society).

Subclass OSTRACODA Latreille, 1802

Order PODOCOPIDA Müller, 1894

Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Sars, 1866

Genus *Cytherelloidea* Alexander, 1929

*Cytherelloidea monodenticulata* n. sp.

Figs. 1 a–e

DIAGNOSIS: Randomly pitted carapace; faint circular central depression in adult, and large centrodorsal toothlike structure in left valve.

DESCRIPTION: In lateral view: carapace slightly narrowing posteriorly; dorsal margin gently convex; ventral margin broadly, gently concave; anterior margin evenly rounded; posterior margin truncate (mature) to rounded (immature); greatest height at anterior; broad rim around all margins, except mid-dorsum, bounded by deep pits (mature) or large reticulations (immature); anteromarginal rim with narrow peripheral ridge, tending to be denticulate in adults; surface of left valve sparsely pitted in low areas, more densely pitted near margins, surface of right valve in penultimate instar smoother than left valve; oblong subcentral depression prominent; dorsal and elongate posterodorsal depression poorly developed. In dorsal view: greatest width just behind center.

Right valve larger and overlapping left valve; strong toothlike projection present in



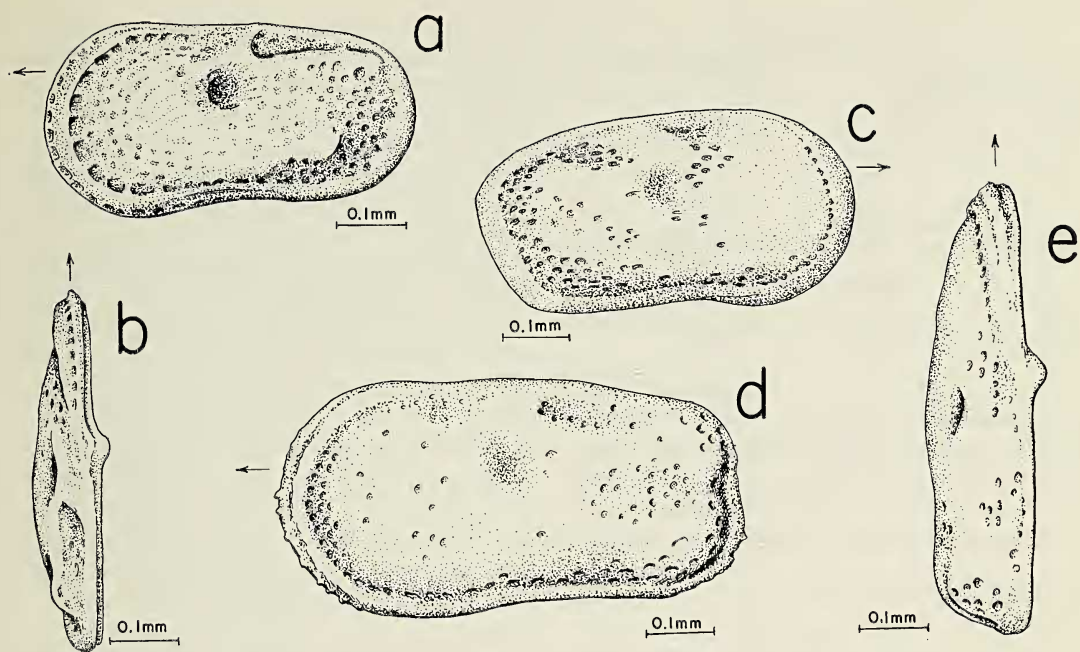


FIG. 1. *Cytherelloidea monodenticulata* n. sp. *a-b*, Paratype SDNH 1025; *a*, side view of penultimate left valve; *b*, dorsal view showing toothlike structure. *c*, Paratype USNM 648713; side view of penultimate right valve. *d-e*, Holotype USNM 648712; *d*, side view of adult female left valve; *e*, dorsal view showing toothlike structure.

mid-dorsum of left valve and equally well developed in penultimate instars; internal features not observed.

DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648712 (left valve, adult ♀)			
T-12	0.67	0.15	0.35
Paratype USNM 648713 (right valve, young)			
T-12	0.58	0.10	0.32
Paratype SDNH 1025 (left valve, young)			
T-12	0.56	0.10	0.30
Paratype USNM 648714 (left valve, young)			
T-12	0.52	0.10	0.30

DISTRIBUTION: As fossils from T-12 (14 valves).

DISCUSSION: The prominent toothlike structure in the mid-dorsum of the left valve is distinctive; apparently it is a persistent feature occurring in both adult and penultimate instars. *Cytherelloidea* sp. of Keij (1953:156) from the Banda Sea, Netherlands East Indies, also shows a prominent tooth although it is not conspecific

with *C. monodenticulata* n. sp. Van den Bold (1963) reviews this phenomenon in other species in the genus.

The fairly smooth exterior, uncontorted by conspicuous depressions save for a subcentral depression, sets this species apart from the great majority of Indo-Pacific *Cytherelloidea*, such as those dealt with by Le Roy (1941), Brady (1880), Kingma (1948), and Keij (1964).

The specific name refers to the single toothlike structure near the mid-dorsum.

Suborder PODOCOPINA Sars, 1866  
Superfamily BAIRDIACEA Sars, 1888  
Family BAIRDIDAE Sars, 1888  
Genus *Bairdia* McCoy, 1844

REMARKS: Sohn (1960:7, 12) points out that more than 600 species of *Bairdia* have been described from Ordovician to Recent ages, but that sexual dimorphism, at least of the hard parts, has gone unnoticed. Kornicker (1961) has shown, however, that certain living species of the genus from the Caribbean have taller males. Similar dimorphism apparently occurs in species of the present study.

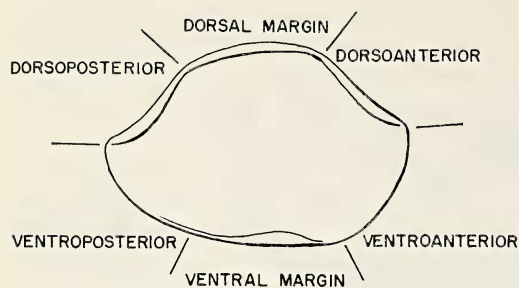


FIG. 2. Terminology of the lateral outline of the genus *Bairdia* (adopted from Sohn, 1960).

Carapace terminology of the *Bairdia* lateral outline has been adopted from Sohn. Unlike the cytheracid carapace, *Bairdia* does not have a posterior and anterior margin per se, these being more conveniently considered as continuations of the dorsal and ventral margins, respectively.

*Bairdia kauaiensis* n. sp.

Figs. 3 a-i

*Bairdia amygdaloides* Brady, 1880. Rept. Voyage *Challenger*, Zool. 1, pp. 54-55, pl. 9, figs.

DIAGNOSIS: Large, somewhat posteriorly-pointed carapace, greatly and evenly inflated; smooth to finely pitted surface; and similarly shaped anterior and posterior vestibules.

DESCRIPTION: Carapace large (maximum length about 1.2 mm); left valve overlapping right valve except at pointed caudal process; ventral and dorsal margins broadly, evenly rounded. Right valve: dorsoposterior slightly concave, sloping about  $40^\circ$ ; dorsal margin straight to slightly convex, sloping about  $10-15^\circ$ ; dorsoanterior straight, sloping about  $30^\circ$ ; ventral margin gently concave; ventroanterior bluntly rounded; ventroposterior slightly concave, entire surface densely but faintly pitted.

Hinge typical for genus; adductor muscle scar pattern of about eight or nine smaller scars, basically five scars encircling a larger scar with two scars below these; two small mandibular scars anterior to lower adductor scars.

Anterior and posterior vestibules equally large, with about same proportions; radial pore canals fairly abundant, straight, simple.

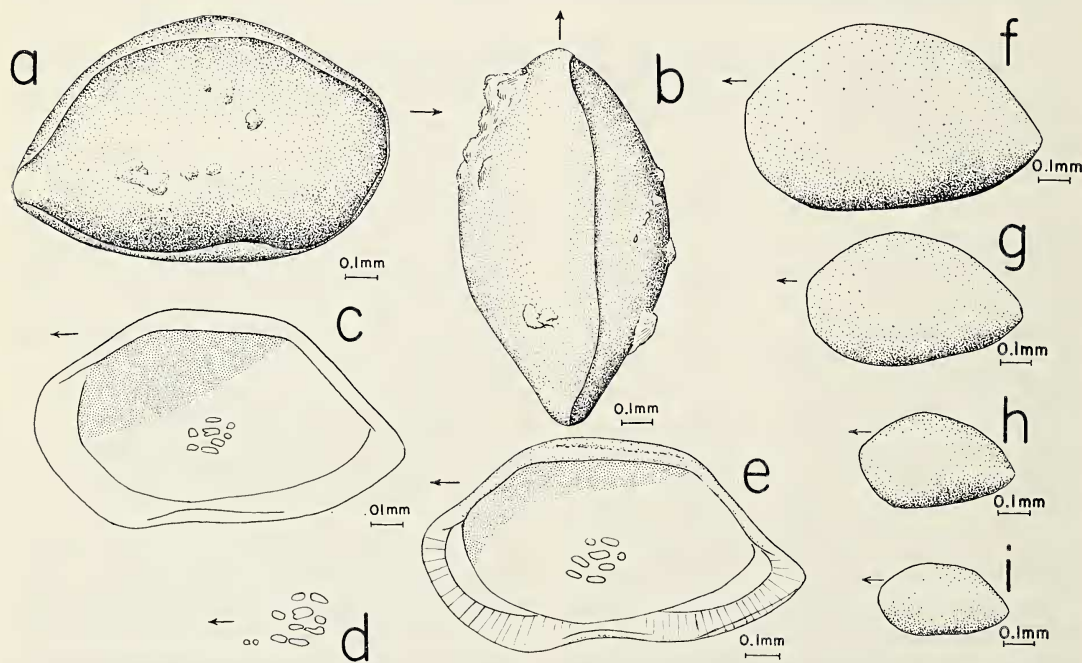


FIG. 3. *Bairdia kauaiensis* n. sp. a-b, Holotype USNM 648719; a, lateral view of female right valve showing overlap of left valve; b, dorsal view. c, Paratype SDNH 1026; internal view of male right valve. d, Paratype USNM 648720; muscle scar pattern of right valve. e, Paratype USNM 648721; internal view of male right valve. f, Paratype SDNH 1027; penultimate left valve. g, Paratype SDNH 1028; left valve of third from last instar. h, Paratype SDNH 1029; left valve of fourth from last instar. i, Paratype SDNH 1030; left valve of fifth from last instar.



TABLE 3  
DIMENSIONS OF *Bairdia kauaiensis* N. SP.

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648719 (entire ♂) T-12	1.20	0.67	0.78
Paratype SDNH 1026 (right valve ♂) T-12	1.20	0.27	0.70
Paratype USNM 648720 (right valve ♀) T-12	1.26	0.30	0.67
Paratype USNM 648721 (right valve ♀) S-23	1.10	0.28	0.65
Paratype SDNH 1027 (penultimate left valve) T-12	0.94	0.30	0.58
Paratype SDNH 1028 (3d from last left valve) T-12	0.68	0.23	0.41
Paratype SDNH 1029 (4th from last left valve) T-12	0.47	0.13	0.28
Paratype SDNH 1030 (5th from last left valve) T-12	0.37	0.11	0.22
Paratype USNM 648722 (left valve ♂) T-12	1.23	0.45	0.80

DIMENSIONS: See Table 3.  
DISTRIBUTION: As fossils from T-1 (8 valves; 2 entire), T-2 (10 valves), T-4 (4 valves; 1 entire), T-7 (4 valves; 2 entire), T-8 (1 entire), T-11 (21 valves; 1 entire), T-12 (82 valves; 7 entire), AR (6 valves; 4 entire), and S-23 (10 valves). Reported by Brady (1880) near Australia at Torres Strait, Humboldt Bay, Hawaiian Islands, Booby Island (10° 36'S, 141° 55'E), and by Brady (1890) at New Caledonia and Fiji. In the East Pacific, found living at Clipperton Island at CL (2 entire), and the Hawaiian Islands at T-13 (10 valves).

DISCUSSION: *Bairdia kauaiensis* n. sp. and *B. amygdaloides* of Brady, 1880 are conspecific, differing only in that the fossils show finer pitting than mentioned by Brady. The type specimen of *B. amygdaloides* from Australia described by Brady in 1866 appears to be a form altogether different from the present forms and those identified with *B. amygdaloides* by Brady in 1880. The type of *B. amygdaloides* is only 0.78 mm long, or about the length of the second- to third-from-last instar of the Hawaiian specimens. Brady (1866:364) mentions that it may be a young; however, it does not bear any resemblances to the young of the new species.

*Bairdia kauaiensis* n. sp. is one of the most commonly occurring ostracodes from the drowned terraces in the Hawaiian Islands. It is present in significant numbers at all stations, including the Recent T-13, but it is absent from the Recent lagoonal assemblage at HA, where *B. banaumaensis* is common and *B. attenuata* is rare.

Little variation occurs in this species except for sexual dimorphism in mature specimens, with the supposed males being taller. The pre-

served population is easily grouped into five molt stages. General shape and inflation, characteristic of mature specimens, is also consistent to the fifth-from-last instar.  
The large adductor muscle scar pattern has diagnostic reliability, with a rectangular middle scar surrounded by about five other scars and two aligned elongate scars below. Using the adductor muscle scar pattern alone, obvious differences can be seen between *B. banaumaensis*, *B. attenuata* (the latter having a very small adductor muscle scar group), and the present species.

The species is named for the island of Kauai, in the Hawaiian Islands.

*Bairdia* sp.  
Figs. 4 a-d

DESCRIPTION: Carapace smooth; highly inflated centroventrally. In lateral view: dorsal margin evenly rounded; dorsoanterior straight; dorsoposterior straight to slightly concave; ventral margin gently concave; ventroanterior bluntly rounded; ventroposterior gently concave; valves unequal; caudal process in right valve pointed, ventrodorsally concave; left valve with poorly developed caudal process. In dorsal view: slightly concave between bulbous center and blunt thick ends.

Adductor muscle scar pattern small, near center; of about 7 or 8 smaller scars; vestibules of moderate size; normal and radial pore canals unobserved.

DIMENSIONS:

SPECIMEN	LENGTH	HEIGHT	WIDTH
USNM 648723 (entire ♀) AR	1.10	0.70	0.70
SDNH 1031 (left valve ♂) AR	1.10	0.75	0.40

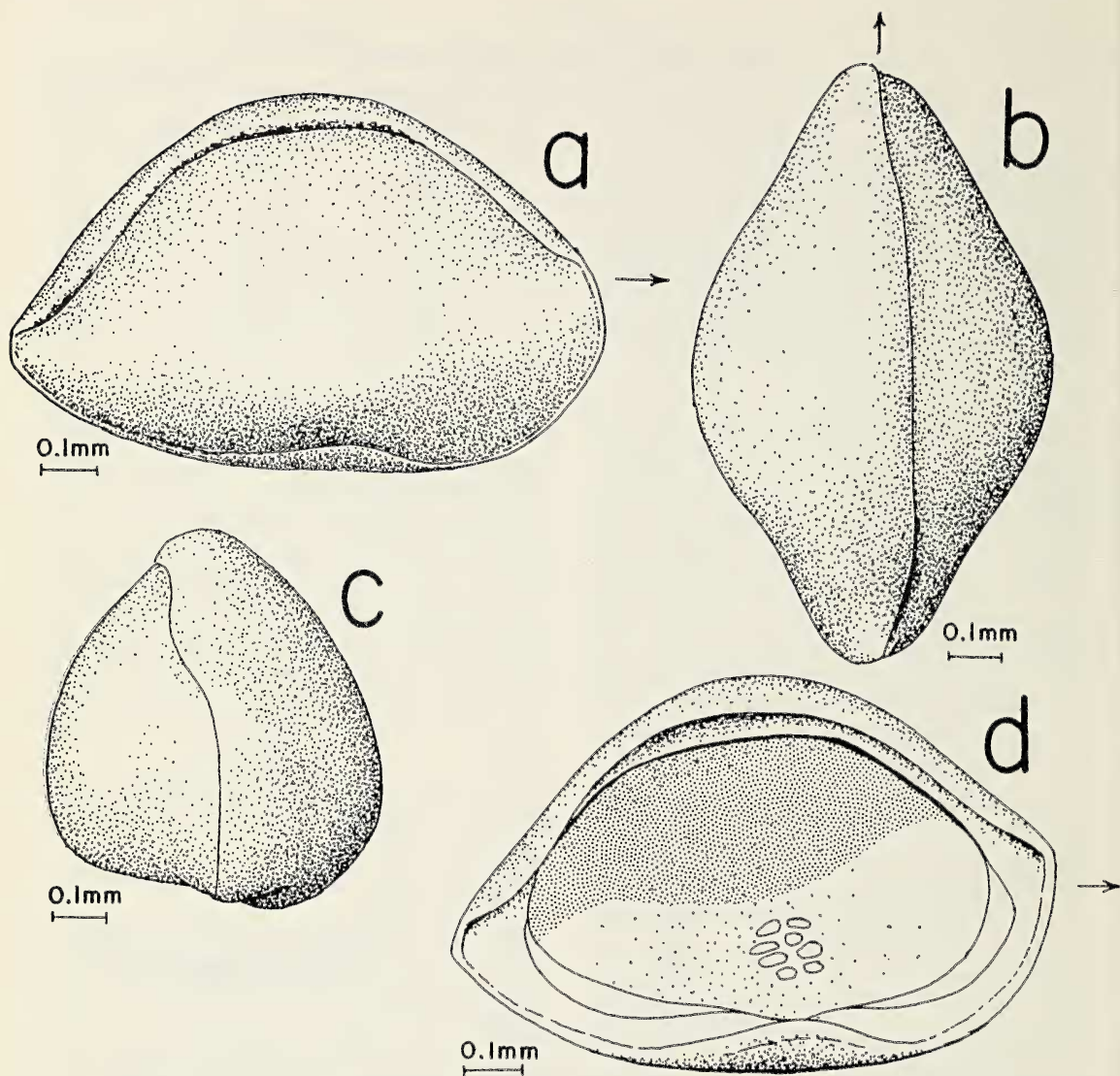


FIG. 4. *Bairdia* sp. *a-c*, Specimen USNM 648723; *a*, lateral right valve view of entire female carapace; *b*, dorsal view; *c*, anterior view. *d*, Specimen SDNH 1031; internal view of male left valve showing ventrally located adductor muscle scar pattern.

**DISTRIBUTION:** As fossils from AR (1 valve; 1 entire).

**DISCUSSION:** Initially, this species was thought to be a dimorphic form of *Bairdia attenuata*. Both species have a distinct concavity in the posterodorsum; but this feature is present only in the smaller right valve of *B. pseudofoveolata*. *Bairdia* sp. is closely related to *B. foveolata* (*partim*) of Brady (1880), who illustrates two forms under this name which are certainly distinct species. The present species resembles

those of his plate 8, figures 1 *a-f*. Excluding figures 2 *a-f* from this discussion, *B. sp.* is wider in dorsal view, and more ventrally inflated in anterior view, than is *B. foveolata* of Brady, 1880. Brady lists *B. foveolata* as ranging in depth from 7 to 1,150 fathoms. Unfortunately he does not specify at which depths the particular "varieties" of that species occur.

The illustration of *Bairdia bradyi* Bold, 1957 (new name for *B. foveolata* Brady, 1868*b*, not Bosquet, 1852), does not closely resemble those



of *B. foveolata* of Brady (1880, figures 1 a-f) or the present species.

*Bairdia banaumaensis* n. sp.

Figs. 5 a-b

DIAGNOSIS: Finely pitted, centrally bulbous, ventrolaterally inflated carapace with ventral caudal process; elongate-oval in dorsal view.

DESCRIPTION: Carapace elongate, length about twice the height. In lateral view: greatest height anterodorsally; dorsoanterior straight, sloping at about  $20^\circ$ ; dorsoposterior straight, sloping at about  $50^\circ$ , ventroposterior and ventral margin continuous, straight; ventroanterior subtruncate, slightly convex. In anterior view: carapace flattened in dorsal half, highly inflated in ventral half. In dorsal view: sides only slightly convex, subparallel; anterior and posterior blunt; surface appears smooth but under high magnification is densely pitted; living individuals evenly covered with short hairs and are uniformly brown in color.

Adductor muscle scar pattern somewhat

variable, usually of nine scars of various sizes and shapes; two antennal scars anterior to lower adductor scars, posterior scar much smaller than other scars; copious mandibular scars just below adductor pattern; several small mandibular scars throughout dorsal half of carapace. Anterior vestibule small; posterior elongate, deepest posteriorly; radial pore canals straight, some bifurcating, with tendency to be paired; hinge typical of genus.

DIMENSIONS: See Table 4.

DISTRIBUTION: As fossils from T-12 (11 valves) and AR (1 valve; 2 entire). Found living at 5 fathoms at HA (15 entire).

DISCUSSION: The low, elongate carapace of *Bairdia banaumaensis* is distinct from the majority of bairdiids. However, *B. acanthigera* of Brady, 1880 and *B. tuberculata* Brady, 1880 also have this general shape, the former being more comparable to *B. banaumaensis* than the latter. *B. acanthigera* of Brady, 1880, from 1,070–1,150 fathoms in the North Atlantic, has a more rounded dorsum and ventral margin

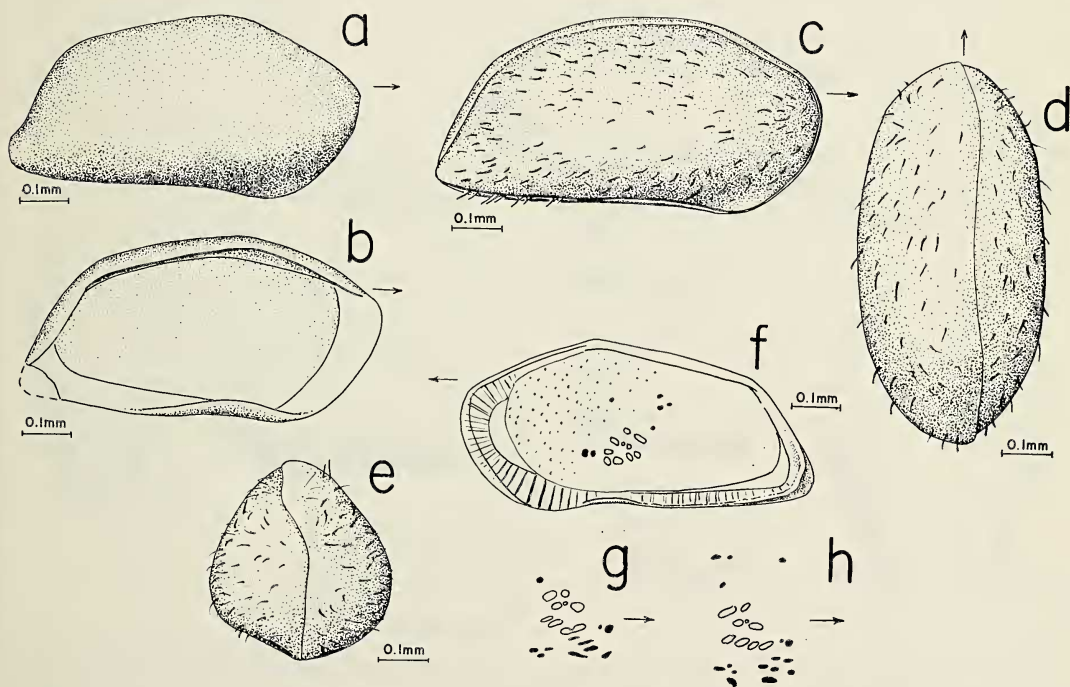


FIG. 5. *Bairdia banaumaensis* n. sp. a, Paratype SDNH 1033; lateral view of right valve. b, Paratype USNM 648727; internal view of left valve. c-e, Holotype USNM 648724; c, lateral view of entire carapace; d, dorsal view; e, anterior view. f, Paratype USNM 648725; internal view of right valve; antennal and mandibular scars in black. g, Paratype SDNH 1032; muscle scar pattern from left valve. h, Paratype USNM 648726; muscle scar pattern from left valve.

TABLE 4  
DIMENSIONS OF *Bairdia hanaumaensis* N. SP.

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648724 (entire) HA	0.75	0.36	0.37
Paratype USNM 648725 (right valve) HA	0.69	0.16	0.33
Paratype SDNH 1032 (left valve) HA	0.70	0.19	0.36
Paratype USNM 648726 (left valve) HA	0.68	0.19	0.34
Paratype SDNH 1033 (right valve) AR	0.71	0.21	0.37
Paratype USNM 648727 (left valve) T-12	0.69	0.22	0.37
Paratype USNM 648728 (left valve) HA	0.68	0.19	0.36
Paratype USNM 648729 (right valve) T-12	0.68	0.15	0.34
Paratype USNM 648730 (entire) HA	0.68	0.32	0.34

and is not as terminally blunt in dorsal view as *B. hanaumaensis*. The tumid *B. tuberculata* from the Admiralty Islands at 16–25 fathoms, though roughly the same shape, is more distinctly ornate and more inflated. The present species is named for Hanauma Bay, Oahu, Hawaii.

*Bairdia ritugenda* n. sp.  
Figs. 6 a–g

DIAGNOSIS: Humped caudal process (terminating with spine in immature specimens), high anterocardinal angle; acuminate posterior; and anteriorly inflated carapace.

DESCRIPTION: In lateral view: carapace pos-

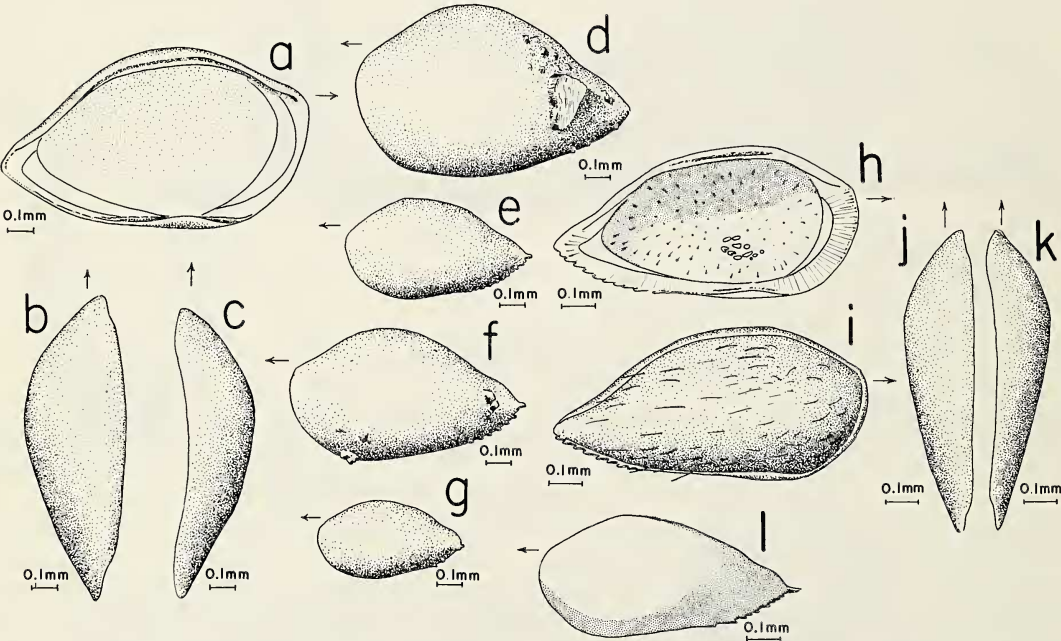


FIG. 6. *Bairdia ritugenda* n. sp. a–b, Holotype USNM 648731; a, internal view of female left valve showing large vestibules; b, dorsal view. c, Paratype USNM 648732; dorsal view of male right valve showing concave dorsum. d, Paratype SDNH 1034; male left valve. e, Paratype SDNH 1035; penultimate left valve showing terminal spine and posteroventral serrations. f, Paratype USNM 648733; third from last instar, left valve. g, Paratype SDNH 1036; fourth from last instar, left valve. h–l, *Bairdia crosskeiana* Brady, 1866; h–k, plesiotype USNM 648735; h, internal view of left valve; i, dorsal view of left valve; j, dorsal view of right valve; k, plesiotype USNM 648736; penultimate instar showing well-developed terminal spine.

teriorly acuminate; greatest height at anterior part of dorsal margin; dorsoposterior with conspicuous dorsally humped caudal process (terminating with spine in young); dorsoanterior slightly concave, sloping at about 30°; ventral margin gently convex, continuous with straight to slightly convex ventroposterior; ventroposterior serrate in young, some adults with occasional denticles; ventroanterior broadly and gently rounded, subtruncate; surface smooth. In dorsal view: carapace posteriorly acuminate; greatest width, like height, just anterior to mid-length; trace of hinge line with left valve broadly arched over right valve.

Duplicature not broad; vestibules large; other internal features obscured.

DIMENSIONS: See Table 5.

DISTRIBUTION: As fossils from T-1 (2 valves; 13 entire), T-2 (6 valves), T-4 (1 valve; 1 entire), T-11 (5 valves; 1 entire), T-12 (28 valves; 10 entire), and AR (1 valve).

DISCUSSION: Other than sexual dimorphism with taller males, little variation occurs in the species. Shape and inflation, characteristic of mature specimens, is also consistent in the young to at least the fourth-from-last instar.

*Bairdia gerda* Benson and Coleman, 1963, from the west coast of Florida, is quite similar to the present species. *B. gerda* differs from *B. ritugerda* only by the lack of the dorsally humped caudal process, the presence of a straighter venter, and by a more pointed dorsum.

*Bairdia crosskeiana* Brady, 1866 of Brady 1880 (a misidentification?) is closely related to *B. ritugerda*, as attested by the presence of a well-developed terminal spine in the young, a humped caudal process, and general shape (though much lower than the former species).

Specimens of *B. crosskeiana* of Brady, 1880 found at T-13 are illustrated for comparative purposes (Fig. 6 b-l).

*Bairdia attenuata* Brady, 1880

Figs. 7 a-d

*Bairdia attenuata* Brady, 1880. Rept. Voyage *Challenger*, Zool. 1, pt. 3, p. 59, pl. 11, figs. 3 a-e.

*Bairdia attenuata* Brady. Egger, J. G., 1901, Abh. Math.-Phys. Cl. koninkl Bayer. Akad. Wiss. 21, no. 2, p. 425, pl. 2, figs. 9, 12.

DIAGNOSIS: Posterior and anterior sharply upturned, especially pronounced in left valves; terminally compressed carapace; high, rounded dorsum.

DESCRIPTION: In lateral view: surface faintly pitted; dorsal margin arched; dorsoanterior and dorsoposterior conspicuously concave; anterior margin slightly convex; ventroposterior broadly rounded; ventroanterior broadly rounded in lower part, tightly rounded in upper part. In dorsal view: carapace compressed, diamond shaped; greatest width medially; ends evenly, sharply acuminate; males taller than females.

Adductor muscle scar pattern of about seven small scars encircling a single larger scar; antennal or mandibular scars not observed. Posterior vestibule shallow, anterior vestibule bilobed, shallow; radial pore canals abundant, simple; normal pores minute, dense.

DIMENSIONS:

	PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648737				
(left valve ♀) S-23		1.05	0.33	0.67
SDNH 1037				
(entire ♂) AR		1.12	0.50	0.70
USNM 648738				
(left valve ♀) T-12		1.05	0.32	0.63

TABLE 5

DIMENSIONS OF *Bairdia ritugerda* N. SP.

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648731 (left valve ♀) T-12	1.17	0.34	0.68
Paratype USNM 648732 (right valve ♂) T-12	1.08	0.24	0.57
Paratype SDNH 1034 (left valve ♂) T-12	1.05	0.34	0.67
Paratype SDNH 1035 (penultimate, left valve) T-12	0.88	0.24	0.50
Paratype USNM 648733 (third from last, left valve) T-12	0.69	0.19	0.40
Paratype SDNH 1036 (fourth from last, left valve) T-12	0.53	0.14	0.30
Paratype USNM 648734 (right valve) T-12	1.00	0.25	0.55



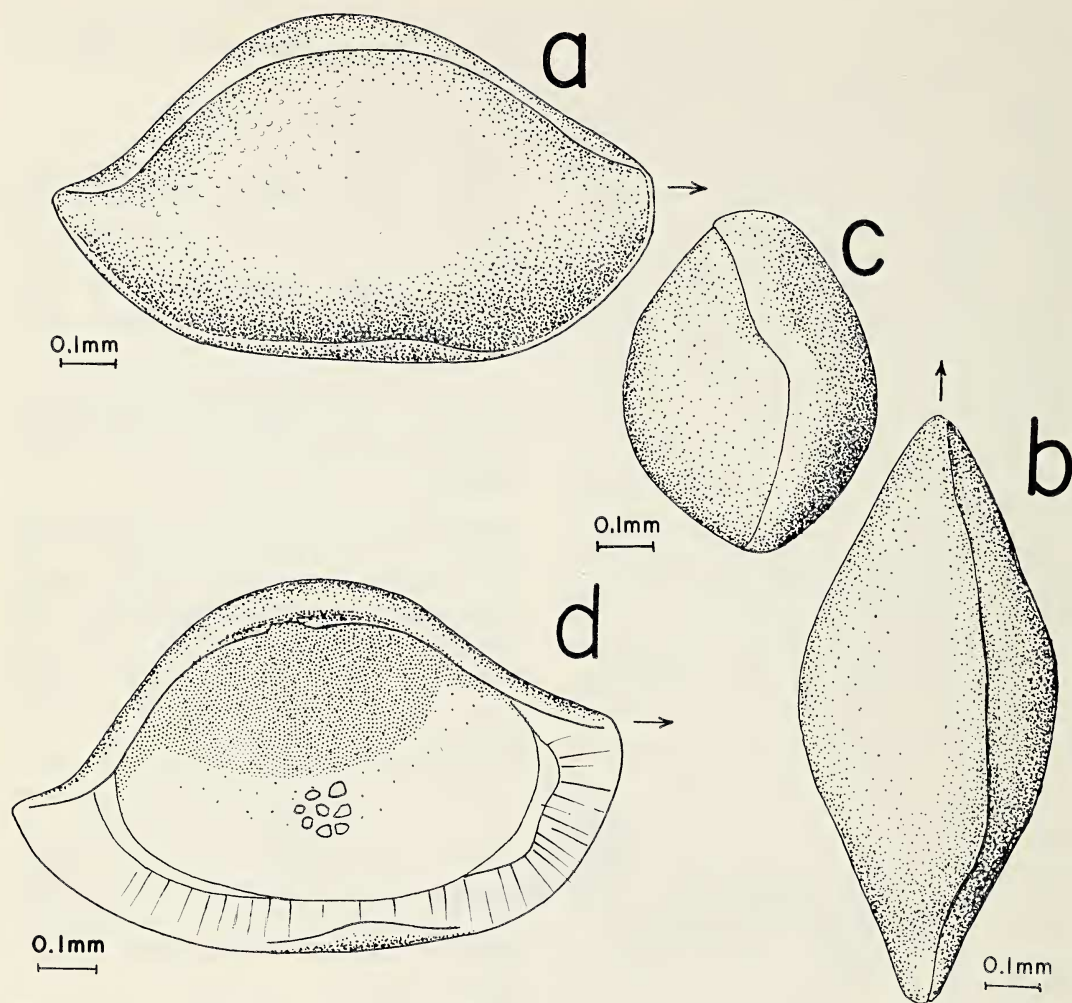


FIG. 7. *Bairdia attenuata* Brady, 1880. *a-c*, Plesiotype SDNH 1037; *a*, right valve of entire male carapace; *b*, dorsal view; *c*, anterior view. *d*, Plesiotype USNM 648737; internal view of female left valve showing adductor muscle scar group.

**DISTRIBUTION:** As fossils from T-1 (1 valve), T-7 (1 valve), T-11 (2 valves; 3 entire), T-12 (13 valves; 1 entire), AR (1 valve; 1 entire), and S-23 (3 valves). Brady (1880:59) reports this species from two dredgings; one at Torres Straits,  $11^{\circ} 35'S$ ,  $144^{\circ} 3'E$ , at 155 fathoms, and one near Hawaii at 40 fathoms. As "young Pliocene" fossils from Timor, Netherlands East Indies (Fyan, 1916:78). Found living at HA (1s) at 5 fathoms. Egger (1901) reports a single valve off the west coast of Africa at 370 fathoms (redeposited?).

**DISCUSSION:** Sexual dimorphism is subtly manifested by a taller male. The similarity of

these specimens to *Bairdia attenuata* of Brady (1880) and Fyan (1916) is close, though the Hawaiian specimens dealt with here show a lower caudal process. Brady (1880), when describing the species, apparently illustrated forms not from Hawaii. Dr. Bate (personal communication) of the British Museum (Natural History), who compared some of the present specimens with Brady's types, also notes that the former have a more upturned posterior and anterior. However, similarities in morphology and the nature of the adductor scar pattern, i.e., size, shape, configuration, and position, suggest that these specimens are conspecific with Brady's form.

*Bairdia expansa* Brady, 1880  
Figs. 8 a-d

*Bairdia expansa* Brady, 1880, Rept. Voyage Challenger, Zool. 1, pt. 3, p. 58, pl. 11, figs. 2 a-e.

DIAGNOSIS: Small, greatly inflated carapace, compressed in antero-posterolateral regions; high anterocardinal angle; abrupt upturned posteroventer; smooth porcelaneous surface.

DESCRIPTION: In lateral view: carapace greatly inflated midventrolaterally; dorsoposterior concave in posterior part, continuous with broadly rounded dorsal margin; dorsoanterior concave; ventroanterior bluntly rounded, with few scattered denticles; ventral margin straight, convex with ventrally extended inflation; ventroposterior abruptly rounded with several den-

ticulations; surface of carapace smooth, apparently imperforate, with porcelaneous texture. In dorsal view: greatest width medially; laterally compressed at ends giving concave lateral extremities; left valve strongly overlapping right valve.

Duplicature moderately wide. Adductor muscle scar pattern apparently large, of many smaller scars.

DIMENSIONS:

PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648739			
(adult left valve)			
T-12	0.84	0.34	0.48±
SDNH 1038			
(penultimate left valve)			
T-12	0.70	0.24	0.40

DISTRIBUTION: As fossils from T-12 (3

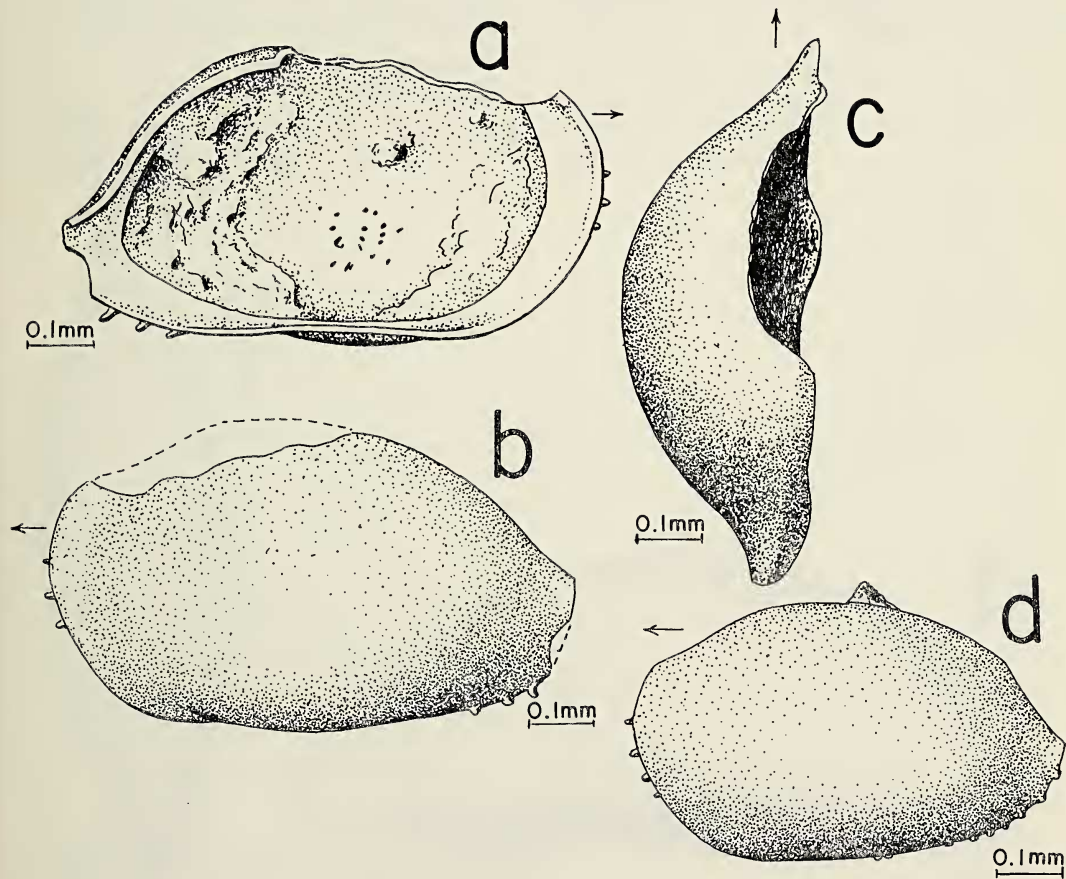


FIG. 8. *Bairdia expansa* Brady, 1880. a-c, Plesiotype USNM 648739; a, internal view of broken left valve; b, lateral view showing dashed line reconstruction; c, dorsal view. d, Plesiotype SDNH 1038; lateral view of penultimate left valve.

valves). Reported living by Brady (1880) in the Hawaiian Islands at 40 fathoms, and by Brady (1890) from tide pools in Samoa.

DISCUSSION: Brady noted that *Bairdia expansa* occurred with *B. amygdaloides* (= *B. kauaiensis*), and *B. crosskeiana* of Brady, 1880 and *B. attenuata*. Its fossil bairdiid association is somewhat different, being with abundant *B. kauaiensis*, common *B. ritugerda*, rare *B. attenuata* and *B. banaumaensis*. *Bairdia crosskeiana* has not been found as a fossil from the Hawaiian Islands.

*Macrocypris gracilis* (Brady), 1890

Figs. 9 a-b

*Pontocypris gracilis* Brady, 1890. Trans. Roy. Soc. Edinburgh 35, p. 491, pl. 1, figs. 5-6.

DIAGNOSIS: Low, elongate, inflated carapace; slightly to moderately concave venter; broadly, evenly arched dorsum.

DESCRIPTION: In lateral view: carapace elongate, length about three times the height; right valve overlapping smaller left valve everywhere except at mid-dorsum; dorsal margin broadly but evenly arched; anterior margin rounded, ventrally extended; ventral margin almost straight, slightly concave at midlength; pointed posterior near venter; surface smooth. In dorsal view: carapace narrow, length about three and a half times width; terminally acuminate with equal posterior and anterior angulation. Internal features not observed.

DIMENSIONS:

PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648715			
(entire) T-4	1.06	0.32	0.39
SDNH 1039			
(right valve) T-4	0.95	0.18	0.39

DISTRIBUTION: As fossils from T-1 (2 valves), T-4 (1 valve: 1 entire), and T-7 (3

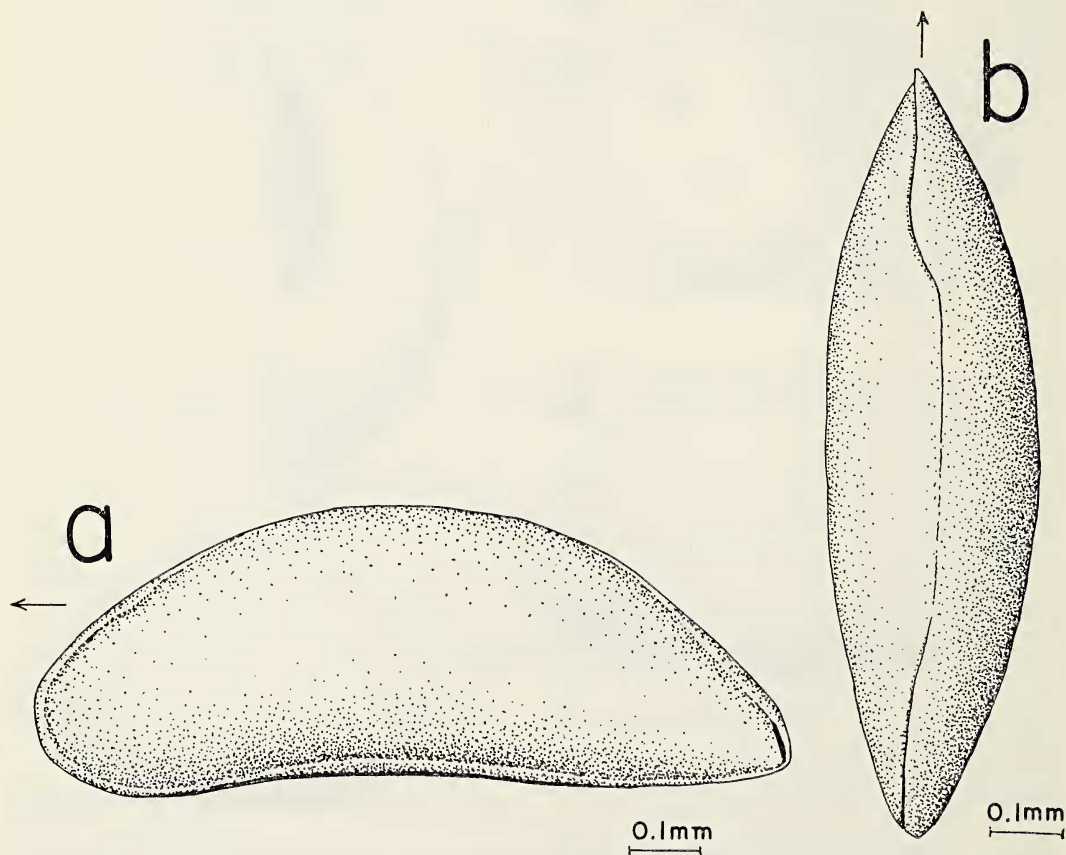


FIG. 9. *Macrocypris gracilis* (Brady), 1890. a-b, Plesiotype USNM 648715; a, lateral left valve view of entire carapace showing overlap of right valve; b, dorsal view.



valves; 2 entire), and from Easter Island at EA-2 (3 valves). Found living at Clipperton Island and by Brady (1890) "between tide marks" at Levuka and Rambe islands in the Fiji Islands.

**DISCUSSION:** The size and shape of the Hawaiian specimens appear identical to *Pontocypris gracilis* Brady, 1890 from the Fiji Islands. However, the species is here assigned to the genus *Macrocypris* on the basis of its shape, smooth margins, valve overlap, and affinities to living *Macrocypris* in the Hawaiian Islands as seen by the writer.

The carapace of *Macrocypris* is most readily confused with that of *Paracypris*, but differs primarily by having a larger right valve, distinct dentition, and more abundant adductor muscle scars.

A feature commonly overlooked in discussions of *Macrocypris* is the dorsal overlap of the right valve by the otherwise smaller left valve. This characteristic is apparent in illustrations of the type species and also occurs in *Macrocypris gracilis* (Brady), 1890.

Superfamily CYPRIDACEA Baird, 1845

Family PROPONTOCYPRIDIDAE Müller, 1894  
Genus *Propontocypris* Sylvester-Bradley, 1947

*Propontocypris simplex* (Brady), 1880

Figs. 10 a-b

*Pontocypris simplex* (Brady), 1880. Rept. Voyage *Challenger*, Zool. 1, pt. 3, p. 37, pl. 1, figs. 5 a-d.

**DIAGNOSIS:** Broadly and evenly rounded dorsum; concave anteroventer; laterally flattened valves.

**DESCRIPTION:** In lateral view: carapace somewhat stout; height almost half the length; dorsal margin broadly arched, greatest height just anterior to middle; anterior margin obliquely rounded, ventrally extended; ventral margin concave in anterior half, convex in posterior half; posterior pointed; right valve larger, overreaching left valve everywhere except at mid-dorsum where left valve overlaps right valve; surface smooth; eye tubercles absent. In dorsal view: width about one-third the length; sides flattened; ends bluntly pointed. Internal features not observed.

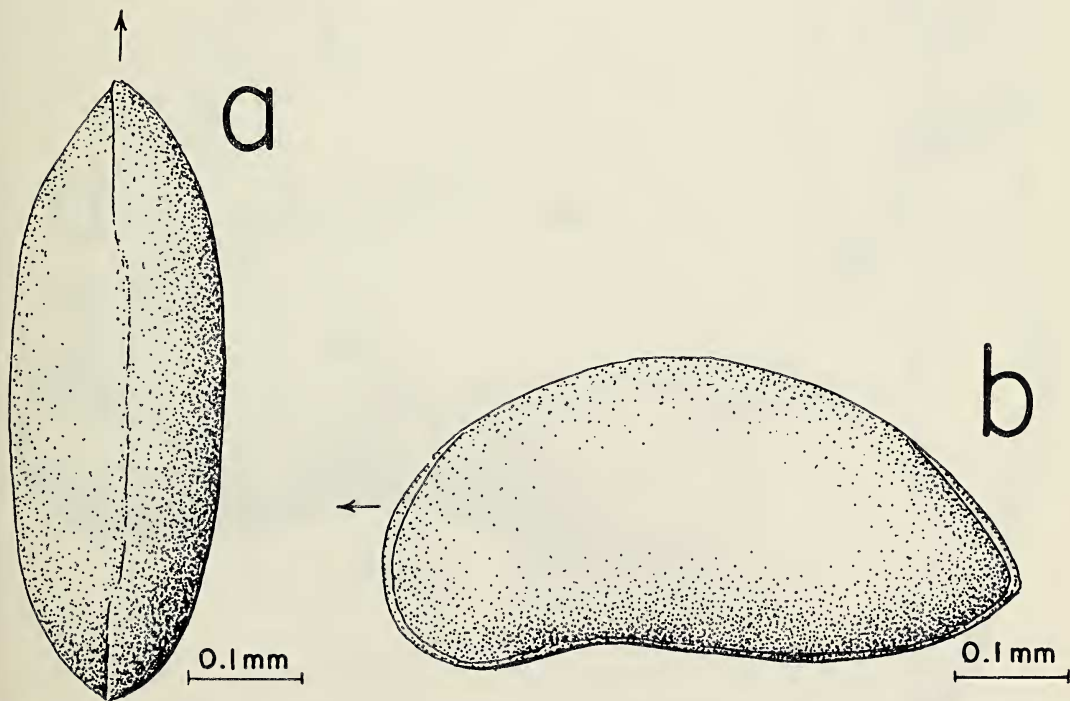


FIG. 10. *Propontocypris simplex* (Brady), 1880. a-b, Plesiotype USNM 648716; a, dorsal view of carapace showing overlap; b, left valve view of carapace showing overlap of right valve.

DIMENSIONS:			
PLESIOTYPE	LENGTH	HEIGHT	WIDTH
USNM 648716			
(entire) T-12	0.55	0.26	0.20
SDNH 1040			
(right valve) T-12	0.62	0.24	0.14

DISTRIBUTION: As fossils from T-12 (2 entire) and Easter Island at EA-2 (1 entire). Reported living from 7 fathoms at Ascension Island, South Atlantic by Brady (1880).

DISCUSSION: Only two carapaces were found from the fossil stations in the Hawaiian Islands, but the general shape and nature of valve overlap agrees with Brady's Recent species from the South Atlantic. This is the only report of this species in the Pacific Ocean.

*Propontocypris simplex* differs from the type species, *Propontocypris trigonella* (Sars), 1866, by having a broadly rounded dorsum, partially concave venter, and a somewhat pointed posterior in lateral view.

*Propontocypris*(?) sp.  
Figs. 11 a-b

DESCRIPTION: In lateral view: length about twice the height, greatest height central; dorsum broadly rounded, anterior half evenly rounded, posterior half irregularly rounded; ventral margin greatly concave in anterior three-fourths, convex in posterior quarter; anterior margin evenly rounded, ventrally extended; posterior margin narrowly rounded; right valve apparently overlapping left valve. In dorsal view: carapace narrow, length three times width; terminally acuminate; sides rounded. Internal features not observed.

DIMENSIONS:			
SPECIMEN	LENGTH	WIDTH	HEIGHT
USNM 648717			
(left valve) T-12	0.57	0.10	0.30
USNM 648718			
(entire young) T-12	0.47	0.15	0.24

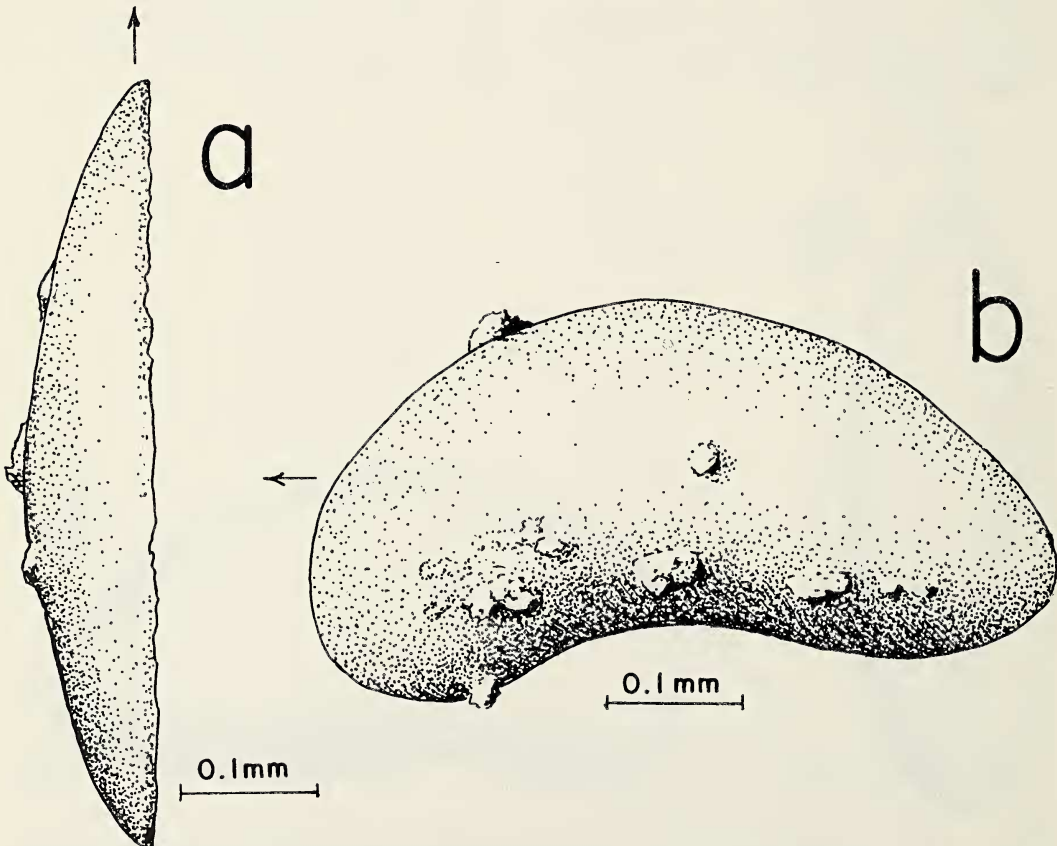


FIG. 11. *Propontocypris* (?) sp. a-b, Specimen USNM 648717; a, dorsal view of left valve; b, lateral view.

**DISTRIBUTION:** As fossils from T-12 (2 entire; 1 valve).

**DISCUSSION:** In lateral view the species possesses characteristics of the genus *Paracypris* but, though preservation is poor, it differs from that genus in the important feature of having a larger right valve.

The species is placed in the genus *Propontocypris* primarily on the basis of general shape, but is placed there questionably because of its pronounced concave venter.

Superfamily CYTHERACEA Baird, 1850  
Family BYTHOCYTHERIDAE Sars, 1926  
Genus *Bythoceratina* Hornibrook, 1952

*Bythoceratina monstrosa* n. sp.

Figs. 12 a-d

**DIAGNOSIS:** Wide, ornate, massive alae, directed straight back and out at an angle of  $30^\circ$  without a terminal spine; pointed caudal process, grotesque anterodorsal tubercle; surface ornamentation of riblets.

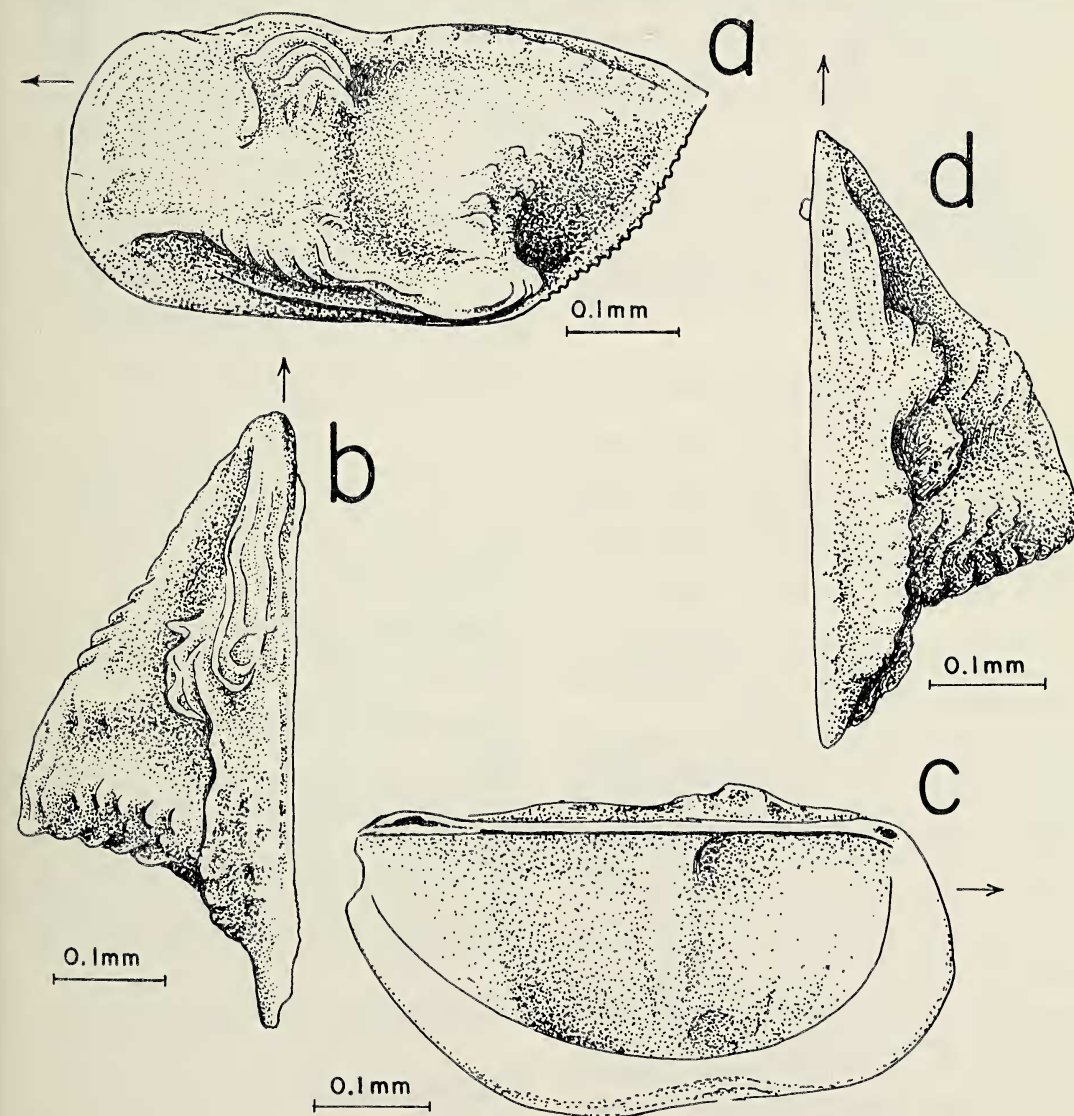


FIG. 12. *Bythoceratina monstrosa* n. sp. a-b, Holotype USNM 648740; a, side view of left valve; b, dorsal view of left valve. c, Paratype USNM 648742; internal view of left valve. d, Paratype USNM 648741; dorsal view of right valve.



DESCRIPTION: In lateral view: dorsal margin sinuous; anterior margin truncate; ventral margin straight, parallel with dorsal margin, curving up posteroventrally about  $45^\circ$  to high pointed posterodorsal caudal process; oblique posterior margin finely and evenly denticulate. Carapace fragile, small; alar processes large, running from ventral part of anterior margin out and back at about  $30^\circ$  to greater than half the length of carapace; dorsal ridge knobby from pointed posterodorsal caudal process to anterior margin; grotesque tubercle just anterior to deep vertical central sulcus; alae intricately ornamented with sinuous parallel riblets in ventral part developing into many small knobs behind alae.

Hingement lophodont: anterior tooth of right valve small, posterior tooth elongate, inconspicuous; median bar of left valve slightly extended, crenulate at ends, otherwise apparently smooth. Duplicature narrow; other internal features not observed.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648740 (left valve) T-12	0.55	0.22	0.27
Paratype SDNH 1041 (left valve) T-12	0.54	0.22	0.27
Paratype USNM 648741 (right valve) T-12	0.55	0.22	0.27
Paratype USNM 648742 (left valve) T-12	0.54	0.21	0.29

DISTRIBUTION: As fossils from T-11 (1 valve), T-12 (13 valves), S-23 (1 valve), and Easter Island at EA-2 (6 valves).

DISCUSSION: This species bears a strong resemblance to two forms from the west coast of North America. One occurrence of a form strikingly similar to *Bythoceratina monstrosa* has been found by the writer in the Coronado Islands 20 miles off San Diego, California. The Recent form is almost identical with the fossil from Hawaii, but differs by having a serrated anterior margin and faint reticulations over most of its surface. Another species of *Bythoceratina* has been observed by the writer in the Pleistocene of Turtle Bay, Baja California, Mexico. These three forms share many similarities and are undoubtedly closely related; however, the Turtle Bay form is clearly a distinct species. *Monoceratina* sp. B of Keij

(1953) is also similar to the new species but lacks several details in ornamentation. The apparently Recent species of Keij occurs in redeposited faunas at 847 and 1,947 fathoms in the Celebes Sea, Netherlands East Indies. The genera *Monoceratina* and *Bythoceratina* have not been previously reported from the west coast of America.

*Bythoceratina monstrosa*, and its North American allies, differ from the New Zealand species of *Bythoceratina* (Hornibrook, 1952: 62-63) in having a smooth median element and knobby alae, lacking a hollow ventrolateral spine. However, one New Zealand species, *B. utilazea* Hornibrook, 1952, from the Lower Miocene to Recent of New Zealand, has close affinity to the present species. These two resemble several Upper Cretaceous *Monoceratina* from South Limburg in the Netherlands, viz., *M. parva*, *M. pygmaea*, *M. sulcata*, *M. pulchra*, and to a lesser degree *M. pseudosulcata*, all of van Veen, 1936. This group is characterized by a dorsally lanceolate shape and the lack of a ventral spine. The species is named for its grotesque ornamentation.

Family CYTHERURIDAE Müller, 1894

Genus *Paracytheridea* Müller, 1894

*Paracytheridea* sp.

Figs. 13 a-b

DIMENSIONS: Specimen USNM 648743 (left valve) T-12: length, 0.31; width, 0.15; height, 0.14.

DISTRIBUTION: As fossils from T-12 (2 valves).

DISCUSSION: Poor preservation and lack of material do not warrant a detailed treatment of the present species. It is possible that the figured specimen, the larger of the two, is a young one, although some species of this genus are not much larger (Morkhoven, 1963:378).

Family HEMICYTHERIDAE Puri, 1953

Genus *Hemicythere* Sars, 1925

*Hemicythere obesa* n. sp.

Figs. 14 a-d

DIAGNOSIS: Large smooth inflated carapace; straight subparallel ventral and dorsal margins;

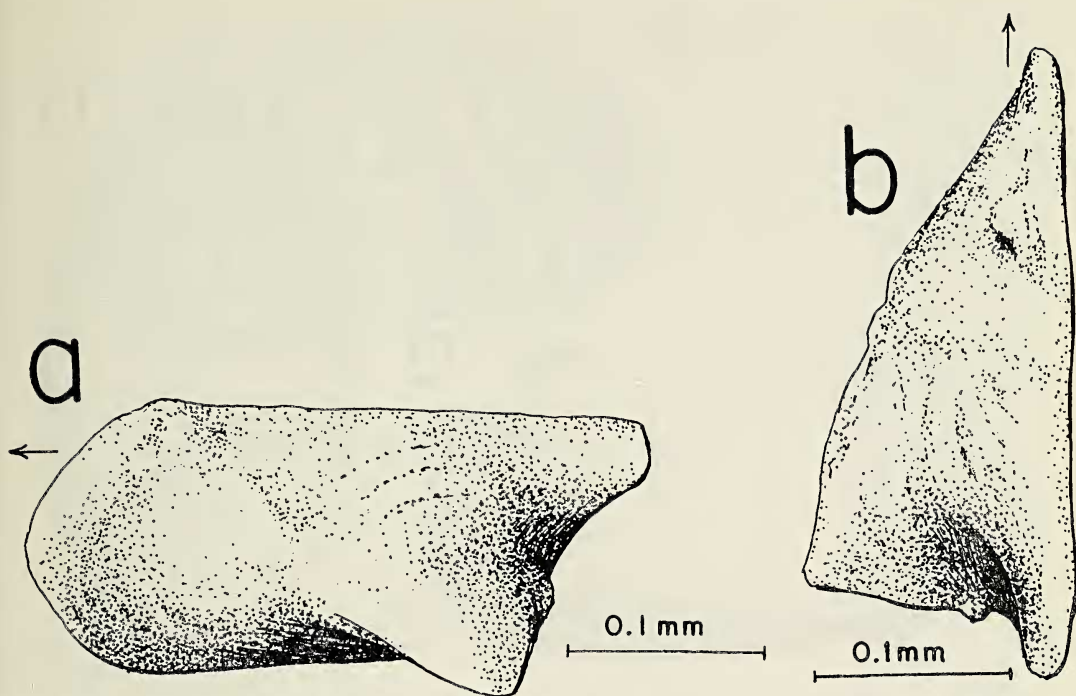


FIG. 13. *Paracytheridea* sp. *a-b*, Specimen USNM 648743; *a*, lateral view of left valve; *b*, dorsal view.

wide faint sulcus, modified holamphidont hinge; adductor muscle scar pattern of at least six scars.

**DESCRIPTION:** Carapace very inflated, widely but faintly sulcate; dorsal margin straight, subparallel to almost straight ventral margin, both slightly converging posteriorly; short postero-dorsal margin straight in left valve, concave in right valve; posteroventral margin rounded, extended, with five or six denticulations; anterior margin broadly rounded, flattened dorsally, finely denticulate in ventral part; left valve overlapping right valve along posterodorsum, at anterodorsal angle, and at ventral inturned area; surface of carapace mostly smooth, sparsely covered with faint pits; narrow ventral ridges continuing partially up anterolateral surface.

**Hinge modified holamphidont:** anterior tooth of right valve small, with subjacent entire socket; median bar smooth; posterior element elongate, notched twice below.

Adductor muscle scar pattern basically six smaller scars on posterior side of small pit: top scar elongate, or crescent shaped, five circular scars below; antennal scar pattern a triangle of three equal scars on anterior side of pit; two

elongate mandibular scars below antennal group, four or more above adductor group. Radial pore canals straight, simple, apparently very dense (not illustrated); no vestibules present; heavy selvage in left valve with corresponding continuous groove in right valve. Interior heavily pitted.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648744 (entire) T-12	0.83	0.43	0.43
Paratype SDNH 1042 (right valve) T-12	0.83	0.22	0.42
Paratype USNM 648745 (right valve) T-12	0.80	0.22	0.42

**DISTRIBUTION:** As fossils from T-11 (1 valve) and T-12 (9 valves; 2 entire).

**DISCUSSION:** The 12 specimens available are poorly preserved and details of the marginal areas are only barely visible using clearing oil and transmitted light. Figure 14 *c* shows only a few of the almost obliterated, apparently abundant radial pore canals. The large marginal pits are exterior, not interior, as might be suggested in the figure.

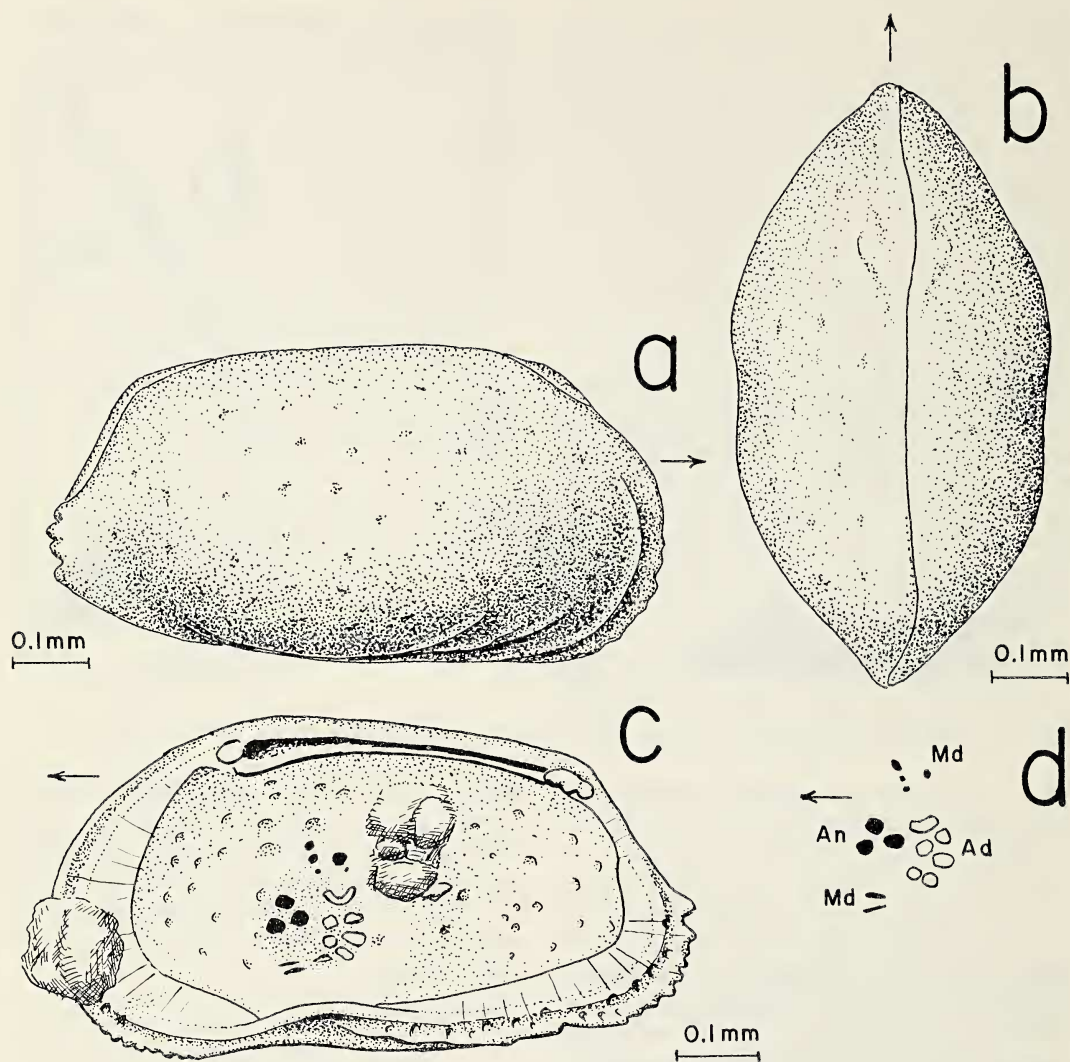


FIG. 14. *Hemicythere obesa* n. sp. a-b, Holotype USNM 648744; a, side view of entire carapace; b, dorsal view of entire carapace; c, Paratype SDNH 1042; internal view of right valve; adductor scars in white. d, Paratype USNM 648745; muscle scar pattern of right valve; adductor scars in white.

The hinge differs from the typical *Hemicythere* amphidont type by being deeply notched beneath the posterior tooth. The species is named with reference to its highly inflated carapace.

*Hemicythere* sp.

Figs. 15 a-c

DESCRIPTION: In lateral view: carapace sub-oval, dorsal margin straight, slightly converging posteriorly with straight ventral margin;

anterior and posterior margins broadly rounded, dorsal part of anterior margin more flattened than ventral part, caudal process absent. Ornamentation distinctive; entire surface covered by distinctly flat-topped ridges continuous in centrolateral parts of carapace and discontinuous near margins of carapace; well-defined concentric pattern centered around area coinciding with internal adductor-antennal muscle scar area; eye tubercles low, indistinct, but well-developed internal ocular sinuses are present.



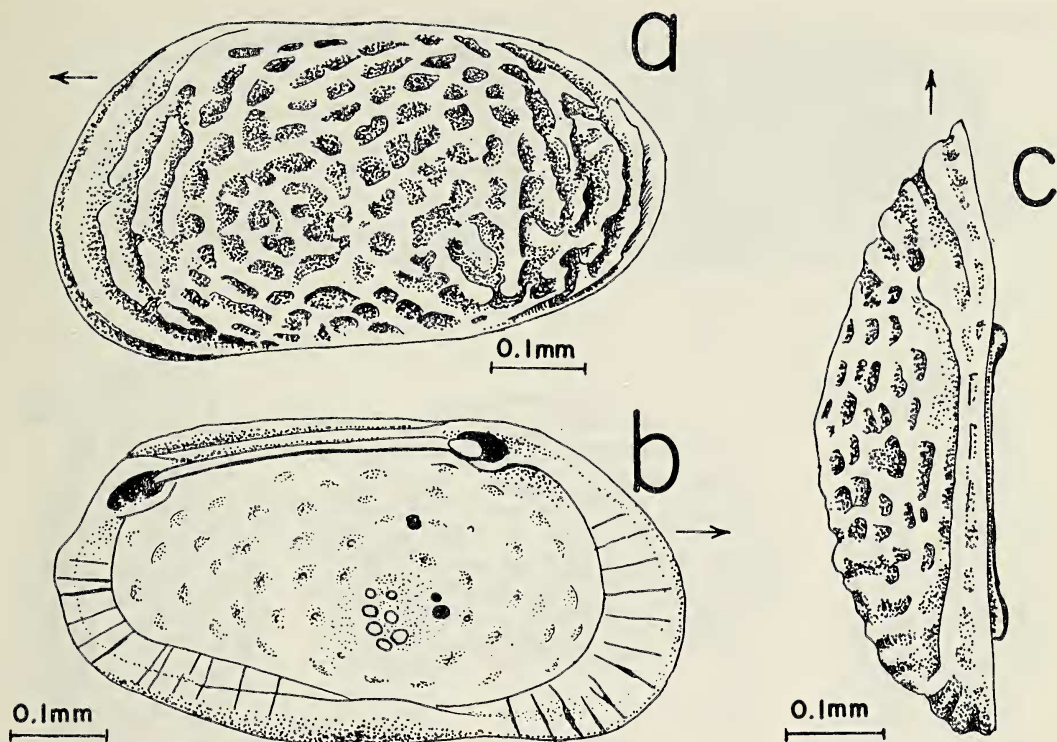


FIG. 15. *Hemicythere* sp. *a-c*, Specimen USNM 648746; *a*, external side view of left valve; *b*, internal view; adductor scars in white; *c*, dorsal view.

Hinge modified holamphidont: posterior element trilobed; anterior element an entire tooth; median bar smooth, with smooth, somewhat subdued anterior tooth, posterior part of bar projecting (in dorsal view).

Adductor muscle scar pattern distinctive: curved, near-vertical row of four rounded scars on side of shallow depression; top, bottom, and one of middle scars divided into two distinct scars respectively; two antennal scars on anterior side of depression; single (?) weak dorsal mandibular scar present. Radial pore canals moderately abundant, straight, few in antero-venter with midswellings; normal pore canals numerous, causing deep internal depressions, pores not coinciding necessarily with external lows (some extend through the heavy ornamentation). Moderate selvage present in left valve.

DIMENSIONS: Specimen USNM 648746 (left valve) T-12: length, 0.65; height, 0.35; width, 0.20.

DISTRIBUTION: As fossils from T-1 (1 valve), T-11 (1 entire), and T-12 (1 valve).

DISCUSSION: *Hemicythere* sp. is in many ways comparable to *H. obesa*. An inflated carapace with large internal pits, ventrally notched posterior hinge element, and general shape are common to both species. *H. sp.*, however, is smaller, coarsely ornamented, and has a different muscle scar pattern than *H. obesa*. Here, as in the latter species, *H. sp.* disagrees with the generic concept by having an almost hemiamphidont hinge and an atypically divided adductor muscle scar pattern.

#### Genus *Mutilus* Neviani, 1928

#### *Mutilus (Mutilus) oahuensis* n. sp.

Figs. 16 *a-b*

DIAGNOSIS: Conspicuous left valve overreach; combined ornamentation of large reticulations; pronounced bladelike marginal and lateral ridges.

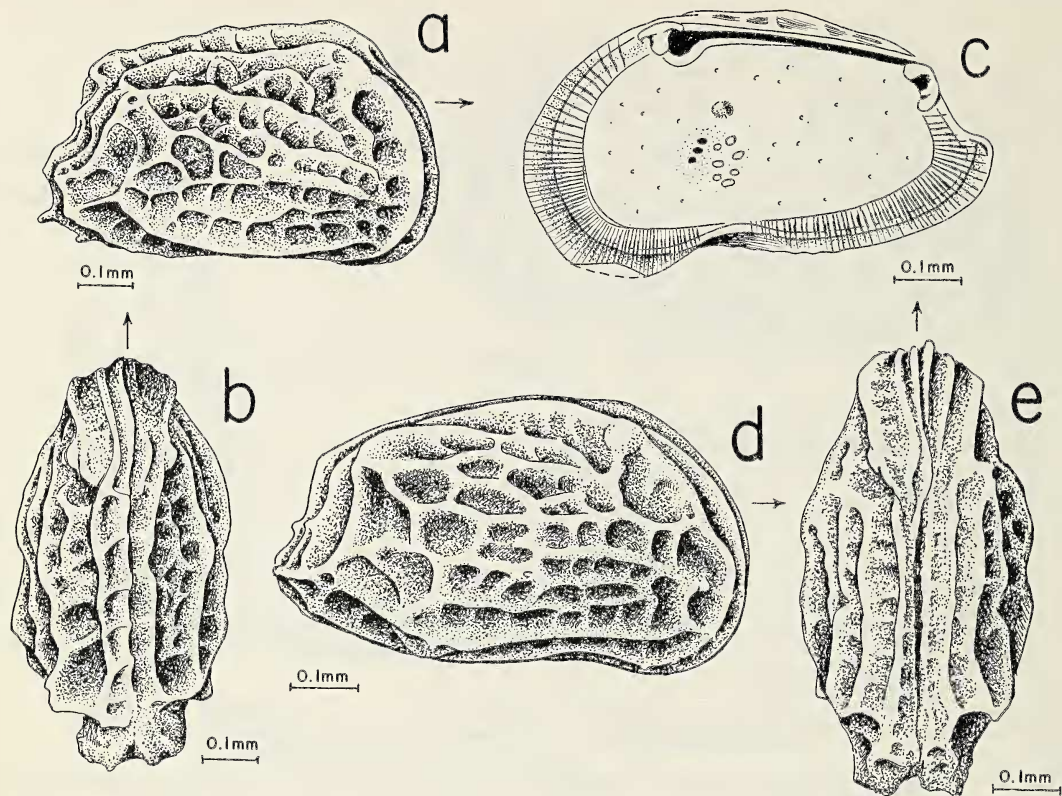


FIG. 16. *Mutilus (Mutilus) oahuensis* n. sp. *a-b*, Holotype USNM 648751; *a*, right valve view of entire carapace showing dorsally overreaching left valve; *b*, dorsal view. *Mutilus (Mutilus) palosensis* (Le Roy), 1943. *c*, Plesiotype USNM 648748; internal view of right valve; adductor scars in white. *d-e*, Plesiotype USNM 648747; *d*, right valve view of entire carapace showing slight overreach of left valve; *e*, dorsal view.

**DESCRIPTION:** In lateral view: anterior margin blunt, somewhat flattened in dorsal part, more tightly rounded in ventral part; ventral margin slightly concave; dorsal margin gently convex in both valves; posterior margin concave above distinct low caudal process. Left valve considerably overreaching but not strongly overlapping right valve dorsally; ornamentation distinctive; surface covered by large deep reticulations bordered by high massive bladeliike ridges; marginal ridges same; dorsal ridge turning abruptly anteroventrally at posterodorsal angle, forming high oblique lateral ridge; ventrolateral ridge also prominent. Eye tubercle below anterodorsal angle indistinct, located at juncture of dorsal and anterior marginal ridges and sinuous vertical ridge. Internal features not observed.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648751			
(entire) AR	0.75	0.39	0.47
Paratype USNM 648752			
(entire) AR	0.72	0.43	0.46
Paratype USNM 648753			
(entire) AR	0.75	0.36	0.45
Paratype SDNH 1043			
(entire) AR	0.70	0.35	0.41
Paratype SDNH 1044			
(entire) AR	0.74	0.37	0.46

**DISTRIBUTION:** As fossils from AR (1 valve; 7 entire).

**DISCUSSION:** The internal features of this species are not preserved; however, a Recent species, *Mutilus palosensis* (LeRoy), 1943, from Alijos Rocks, Mexico, most certainly a



closely related form, has typical hemicytherid internal features. Specimens from Alijos Rocks are illustrated for comparative purposes (Figs. 16 *c-e*). Though very similar in general shape and ornamentation, the Hawaiian fossil species is shorter, the larger left valve is relatively higher than the right valve, and the dorsum is straight. Also, the reticulations in the fossil form are deeper and the ridges more bladelike than in *M. palosensis*.

*Mutilus (?) coalescens* n. sp.

Figs. 17 *a-d*

DIAGNOSIS: Ornamentated with coalescing

heavy knobs and poorly defined ridges; highly inflated, subquadrate carapace.

DESCRIPTION: Carapace tumid, as wide as high or wider; left valve slightly larger, overlapping right valve at terminal hinge elements and ventral intumed area. In lateral view: dorsal margin straight to slightly convex; anterior and posterior margins subtruncate, anterior margin sloping down about  $60^\circ$  from the horizontal from sharp anterodorsal angle; posterior margin straight, sloping down about  $75^\circ$  from sharp posterodorsal angle to inconspicuous low caudal process; ventral margin straight to slightly concave, terminating at caudal process.

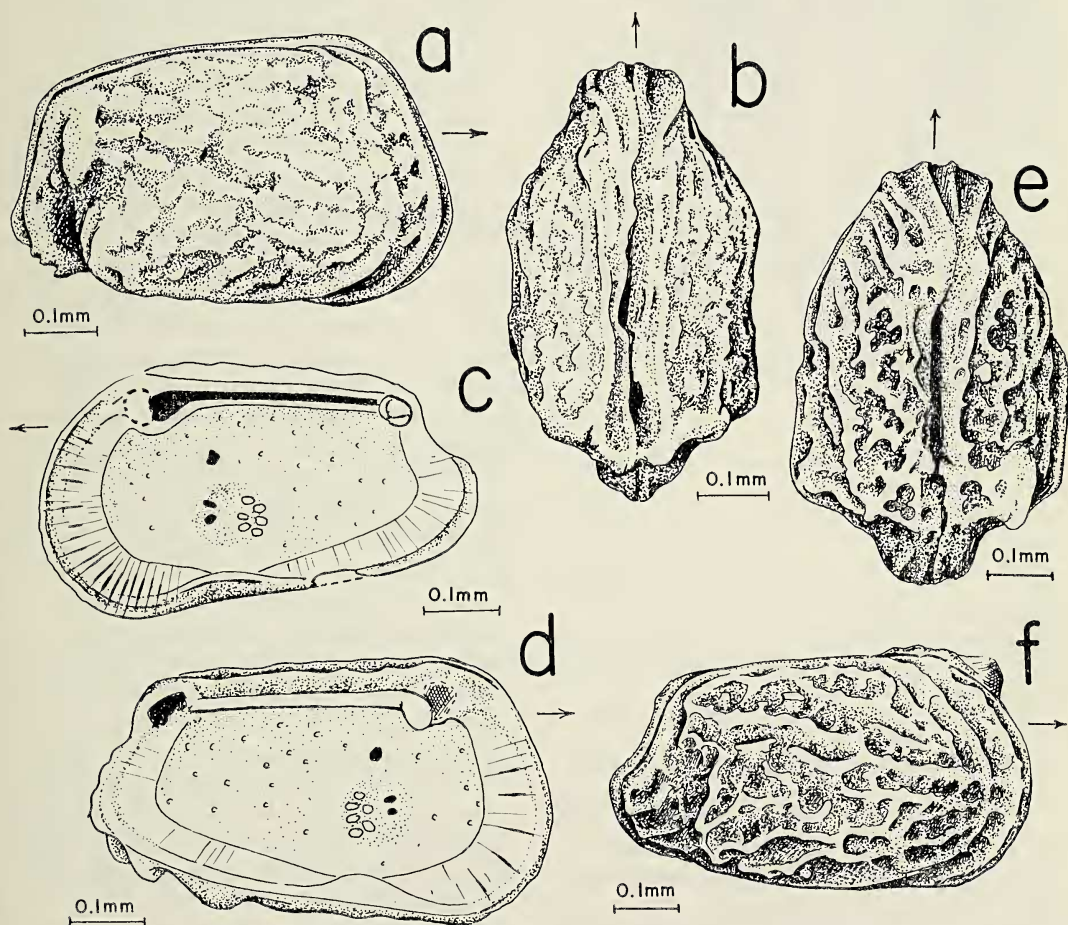


FIG. 17. *Mutilus (?) coalescens* n. sp. *a-b*, Holotype USNM 648762, right valve view of entire female (?) carapace; *b*, dorsal view. *c*, Paratype USNM 648763; internal view of female (?) right valve; adductor scars in white. *d*, Paratype SDNH 1045; internal view of male (?) left valve; adductor scars in white. *e*, Paratype USNM 648764; dorsal view of entire female (?) showing deep dorsal groove. *f*, Paratype SDNH 1046; right valve view of entire male (?) showing slight overlap of left valve.



In dorsal view: carapace inflated, greatest width at subcentral swelling and posteroventral extension; broad inconspicuous central sulcus present; caudal process relatively compressed; anterior blunt, with two smooth marginal ridges per valve, converging at anterodorsal angle. Ornamentation heavy, complex, distinctive, of distinct or coalescing heavy knobs and ill-defined ridges with general horizontal trend, adjacent depressions partially filled with secondary (?) growth; marginal ridge of ventral inflation extending around anterolateral surface to well-defined eye tubercle, paralleling outer anterior marginal ridge.

Hingement essentially holamphidont: terminal teeth of right valve entire (posterior tooth faintly trilobed); median bar of left valve heavy, smooth anterior tooth entire.

Adductor muscle scar pattern four in a row on side of deep pit, second and bottom scars divided into two scars; two antennal scars, one above the other, deep within pit; single mandibular scar just dorsal to pit. Radial pore canals very abundant, straight, single, many in anterior with midswellings; no vestibules present; normal pore canals large, sparse; flange in left valve and flange groove in right valve heavy, well developed.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648762 / (entire ♀ ?) S-23	0.64	0.37	0.39
Paratype SDNH 1045 (right valve ♀ ?) S-23	0.63	0.18	0.39
Paratype USNM 648763 (left valve ♂ ?) S-23	0.67	0.19	0.40
Paratype USNM 678764 (entire ♀ ?) AR	0.65	0.41	0.37
Paratype SDNH 1046 (entire ♂ ?) AR	0.67	0.44	0.40

DISTRIBUTION: As fossils from S-23 (4 valves; 1 entire) AR (2 valves; 2 entire).

DISCUSSION: Aspects of shape, ornamentation, and musculature of this species are not typical of others in the genus; for this reason the generic assignment is questioned. Two forms occur in the collection, differing only in the degree of development of ornamentation. Specimens illustrated in Figures 17 *a-d* from station S-23 possess relatively heavier ridges than

those in Figures 17 *e-f* from station AR. These differences are not considered to be of specific importance, however.

Brady's species of *Cythere fungoides* (1880: pl. 19, fig. 7) is similar in shape to *Mutilus*(?) *coalescens* although they differ in ornament. Unfortunately, the internal features of *C. fungoides* are unknown and the relationship between these two forms is obscure.

#### Genus *Jugosocythereis* Puri, 1957

#### *Jugosocythereis venulosus* n. sp.

Figs. 18 *a-c*

DIAGNOSIS: Carapace short, inflated; ornamentation of small reticulations aligned in stripes; subcentral tubercle pitted (without the ridges which are typical of the genus).

DESCRIPTION: In lateral view: dorsal margin straight to slightly convex with small central hump; ventral margin straight, curving upward abruptly at posterior, ending at weak, pointed caudal process; posterodorsal margin weakly concaved above caudal process; anterior margin blunt, smooth, evenly rounded. In dorsal view: carapace tumid, about as wide as high; equally wide at subcentral and posteriorly directed posteroventral tubercles; prominent posterodorsal tubercle present; margins smooth save for some inconspicuous wide spines in posteroventer; left valve larger and strongly overlapping right valve above terminal hinge elements; ornamentation unique: deep pits coalescing into narrow horizontally trending furrows, giving shell a striped appearance; eye tubercle broad, deep-set, with postjacent prominent pit.

Adductor muscle scar pattern partially obscured; one of middle scars divided; two antennal scars on anterior side of pit, large mandibular scars above subcentral pit, double mandibular scar below pit. Anterior and posterior vestibules narrow; radial pore canals obscure, apparently straight and simple, with some midswellings; normal pores small, sparse. Hingement probably hol- or hemiamphidont.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 678765 (entire) T-12	0.61	0.36	0.39
Paratype SDNH 1047 (right valve) T-12	0.62	0.17	0.36
Paratype USNM 648766 (entire) T-12	0.61	0.35	0.36

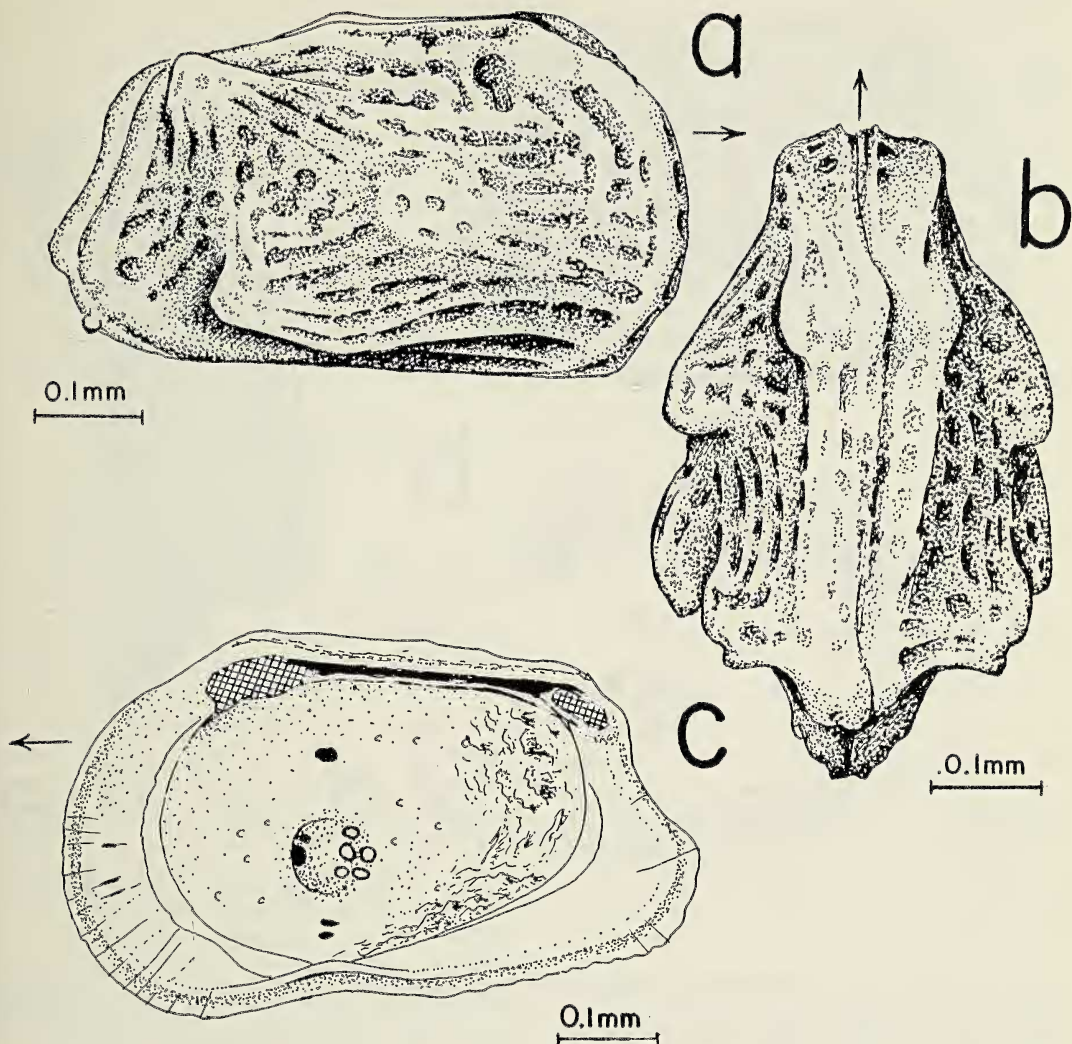


FIG. 18. *Jugosocythereis venulosus* n. sp. a-b, Holotype USNM 648765; a, lateral right valve view of carapace showing overlap of left valve; b, dorsal view. c, Paratype SDNH 1047; internal view of poorly preserved right valve; adductor scars in white.

DISTRIBUTION: As fossils from T-11 (1 entire) and T-12 (5 valves; 3 entire).

DISCUSSION: This species represents an extreme form of ornamentation for *Jugosocythereis*. The surface is finely reticulate and practically without the characteristic small ridges. Also, the subcentral swelling, alae, and posterodorsal complex are extremely tuberculate and localized. Sexual dimorphism in the species is not apparent. The species is named for its veinlike ornamentation.

Genus *Quadracythere* Hornibrook, 1952

*Quadracythere hornibrooki* n. sp.

Figs. 19 a-e

DIAGNOSIS: Smooth median bar; trilobed posterior tooth; smooth anterior margin; divided adductor muscle scar pattern.

DESCRIPTION: Carapace stout, inflated, subquadrate. In lateral view: slightly concave dorsal margin symmetric with convex ventral margin; posterior margin concave in upper part, forming low caudal process in lower part; poorly devel-



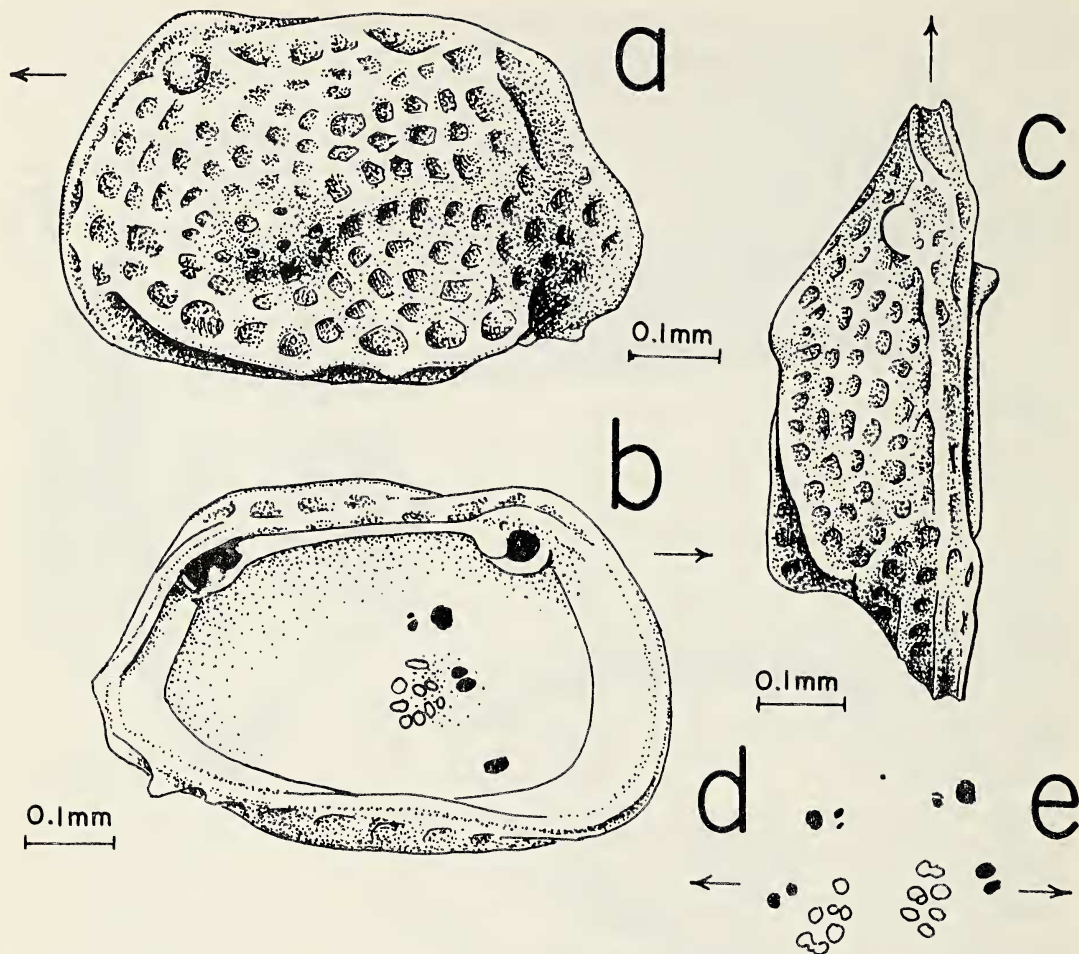


FIG. 19. *Quadracythere hornibrooki* n. sp. a-c, Holotype USNM 648758; a, lateral view of left valve; b, internal view; adductor scars in white; c, dorsal view. d, Paratype USNM 648760; muscle scar pattern of right valve. e, Paratype USNM 648761; muscle scar pattern of left valve; adductor scars in white.

oped narrow ridge from eye tubercle along dorsum turning down in posterodorsal area forming sinuous median ridge terminating at subtle sub-central tubercle; prominent ventral ridge posteriorly extended forming weak alae; surface with large, deep various-sized reticulations.

Dentition holamphidont: median element of left valve a smooth bar with stubby anterior tooth, bar thickening posteriorly; posterior tooth of right valve entire, reniform; posterior socket of left valve with small ventral and posterior teeth.

Adductor muscle scar pattern complex; top scar entire, second scar down divided into two or three scars, bottom two scars variously divided into 3-5 smaller scars. Two antennal scars

located anterior to upper adductor scars, large dorsal mandibular scar present. Normal pores of sieve type, large, forming deep pits internally.

DIMENSIONS: See Table 6.

DISTRIBUTION: As fossils from T-2 (1 valve), T-11 (1 valve), and T-12 (26 valves; 2 entire).

DISCUSSION: Generic discrepancies in dentition and musculature exist between species of typical *Quadracythere* from New Zealand and the present species. In the latter, the median bar is smooth, not crenulate, and the adductor scar pattern is usually divided.

The Hawaiian individuals are somewhat comparable to *Quadracythere mediaruga* Hornibrook (Kaiatan-Recent, New Zealand) in shape and placement of ridges, but lack the antero-



TABLE 6  
DIMENSIONS OF *Quadracythere hornibrooki* N. SP.

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648758 (left valve) T-12	0.77	0.21	0.50
Paratype USNM 648759 (left valve) T-12	0.75	0.22	0.50
Paratype SDNH 1048 (right valve) T-12	0.80	0.22	0.52
Paratype SDNH 1049 (left valve) T-12	0.80	0.25	0.50
Paratype USNM 648760 (right valve, young) T-12	0.69	0.18	...
Paratype USNM 648761 (left valve) T-12	0.77	0.26	0.52

marginal denticulations and are more ovate in lateral outline.

Genus *Loxoconcha* Sars, 1866

*Loxoconcha batei* n. sp.

Figs. 20 *a-b*

DIAGNOSIS: Straight dorsal margin; evenly inflated carapace; extremely complicated ornamentation of high, flat-topped discontinuous ridges surrounded by less pronounced network of reticulations.

DESCRIPTION: In lateral view: carapace oblong; dorsal margin straight; ventral margin gently convex, curving upward posteriorly forming subtle arcuate posteroventral ridge; anterior margin usually broadly rounded; posterior margin straight, sloping upward 60° in ventral half; ornamentation distinctive: heavy discontinuous flat-topped ridges and flat-topped spines rising high above a coarsely reticulate lower surface; large low eye tubercles present. Carapace evenly inflated in dorsal view.

Hinge gongylodont: left valve anterior element a short rounded tooth, postadjacent socket and smaller tooth; median element a crenulate bar; posterior element a very small socket, round postadjacent tooth, and larger socket, sockets interconnected. Well-developed accommodation groove present above median element of left valve.

Adductor muscle scar pattern an arcuate row of four smaller quadrate scars on slight median ridge (not expressed as an external sulcus), lowest scar in front of top three scars; quadrate antennal scar in front of top two adductor scars; radial pore canals not observed; no vestibules present; heavy continuous selvage along duplicature of left valve with corresponding heavy groove in right valve.

DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648771 (left valve ♂) T-12	0.58	0.20	0.35
Paratype SDNH 1050 (right valve ♂) T-12	0.58	0.18	0.33
Paratype SDNH 1051 (left valve ♀) T-12	0.53	0.20	0.34
Paratype USNM 648772 (left valve ♂) T-12	0.59	0.20	0.36

DISTRIBUTION: As fossils from T-1 (1 valve), T-7 (1 valve), T-11 (3 valves), T-12 (16 valves; 1 entire), and S-23 (1 valve).

DISCUSSION: The ornamentation of this species is very distinctive. The high ridges show no organized pattern but are flat-topped and widest on top, forming a distinct upper surface above and apart from the lower reticulations.

The species is named in honor of Dr. R. H. Bate of the British Museum (Natural History).

*Loxoconcha condyla* n. sp.

Figs. 21 *a-b*

DIAGNOSIS: Straight dorsal margin; ornamented with small poorly defined reticulations; compressed postroventral margin beneath a high caudal process; weak pointed posterodorsal tubercle.

DESCRIPTION: In lateral view: carapace elongate, length about twice the height; dorsal margin straight, anterior margin somewhat obliquely rounded; ventral margin beneath high caudal process constricted into posteroventral keel. In dorsal view: carapace sublenticular, compressed behind poorly developed dorsal tubercles near posterior; greatest width central at broad subcentral swelling. Ornamentation of poorly defined small reticulations (or large pits); anteromarginal ridge grooved by row of small pits; eye tubercles well developed.

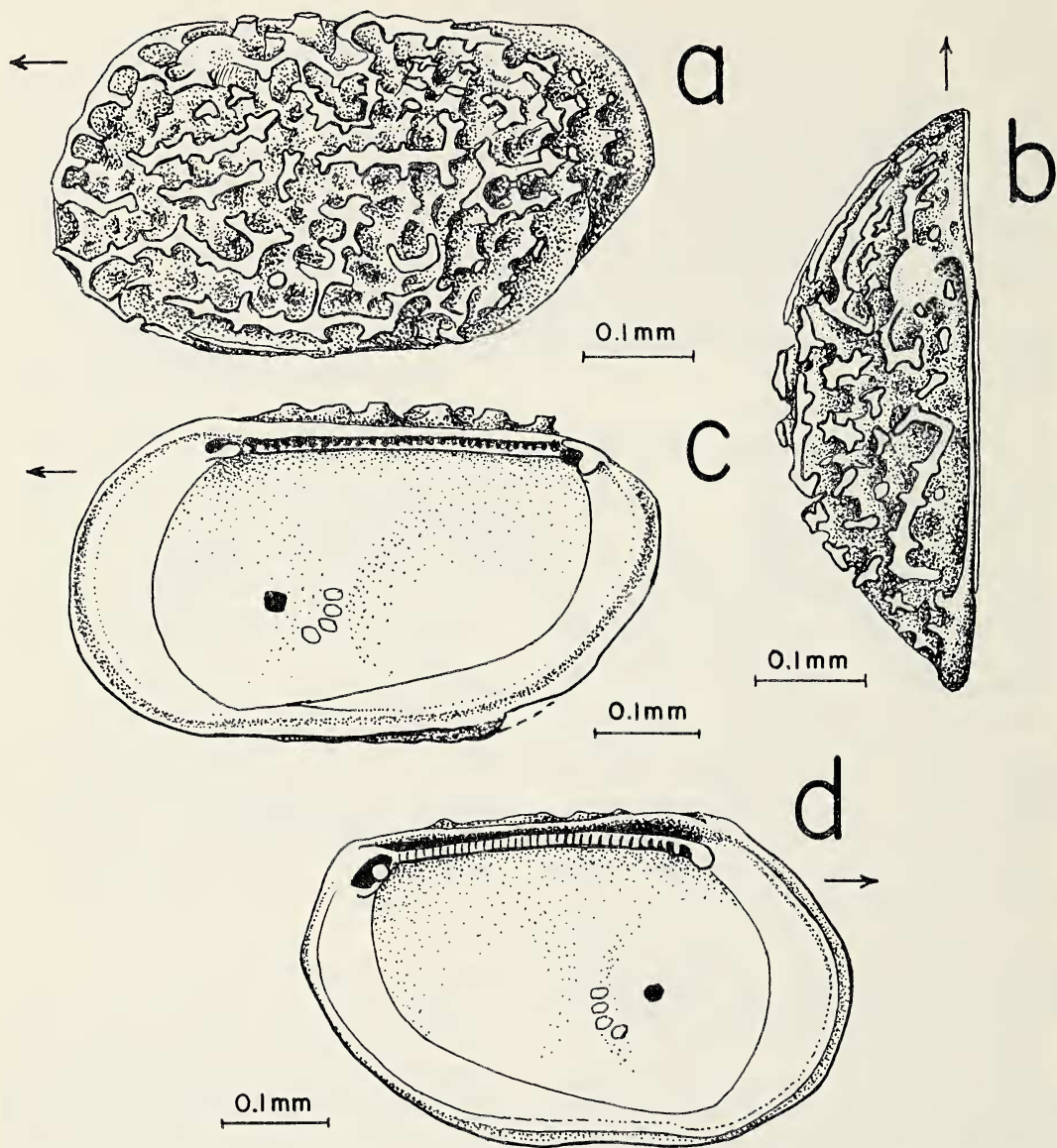


FIG. 20. *Loxoconcha batei* n. sp. *a-b*, Holotype USNM 648771; *a*, lateral view of male left valve; *b*, dorsal view. *c*, Paratype SDNH 1050; internal view of male right valve; adductor scars in white; marginal features not preserved. *d*, Paratype SDNH 1051, internal view of female left valve; adductor scars in white; marginal features not preserved.

Duplicature of moderate width; radial pores sparse, straight, simple; vestibules absent; normal pores somewhat abundant, of intermediate size, apparently corresponding with external pits. Adductor muscle scar pattern of four small scars in short vertical row, third from top scar divided; two antennal scars in front of adductor group.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648773 (entire) T-12	0.51	0.24	0.29
Paratype USNM 648774 (left valve) T-12	0.48	0.13	0.29

DISTRIBUTION: As fossils from T-12 (7 valves), and S-23 (1 entire); Recent from HA

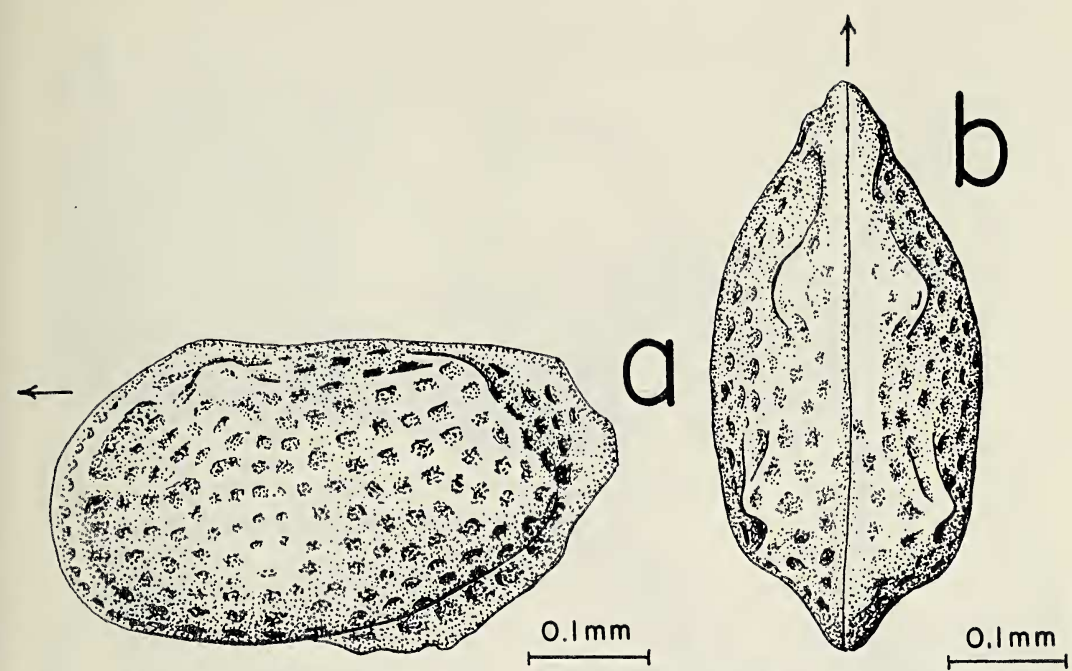


FIG. 21. *Loxoconcha condyla* n. sp. a-b, Holotype USNM 648773; a, lateral left valve view of entire carapace; b, dorsal view.

(6 valves; 5 entire); T-13 (2 valves; 1 entire).

DISCUSSION: *Loxoconcha postdorsolata* Puri, 1960 from the Gulf of Mexico and *Loxoconcha condyla* are similar. The latter does not have the large posterodorsal tubercle that the former has; it does, however, possess a small pointed extension of the carapace in the same area.

Recent representatives of the species occur in the Hawaiian Islands at 22 fathoms on Penguin Bank and at 5 fathoms in Hanauma Bay. At both Recent stations specimens are much smaller than the fossils, i.e., only 0.44 mm in length. In all other aspects the Recent forms appear conspecific with the fossil forms. The description of the internal features was taken from these better preserved specimens.

The species is named with reference to the small, knuckle-like enlargement in the postero-dorsum. This feature is variably developed, being practically absent in some individuals.

*Loxoconcha* sp.  
Figs. 22 a-b

DESCRIPTION: In lateral view: shell sub-rhomboidal; length twice the height; dorsum straight in anterior half, undulatory in posterior half, parallel with straight ventral margin; an-

terior margin bluntly rounded; posterior margin bluntly pointed in dorsal half; ornamentation of faint random pustules. In dorsal view: shell conspicuously sulcate toward posterior; anterior pointed; posterior blunt.

Hinge gongylodont: posterior element of right valve a socket bracketed by two teeth connected above; anterior element a tooth bracketed by two sockets; other internal features obscured.

DIMENSIONS: Specimen USNM 648775 (right valve) T-12: length, 0.52; width, 0.13; height, 0.28.

DISTRIBUTION: As fossil from T-12 (1 entire).

DISCUSSION: Lack of adequate specimens prohibits a more detailed description of the species. The single right valve is unquestionably fossil, as attested by the partial encrustation of manganese oxide on its outer surface (Fig. 22 b).

To the writer's knowledge there are no known pustulose species in the genus *Loxoconcha*. The pustules on the present species are probably a secondary effect caused by corrosion, the sieve pores being somehow more resistant than the remainder of the valve.



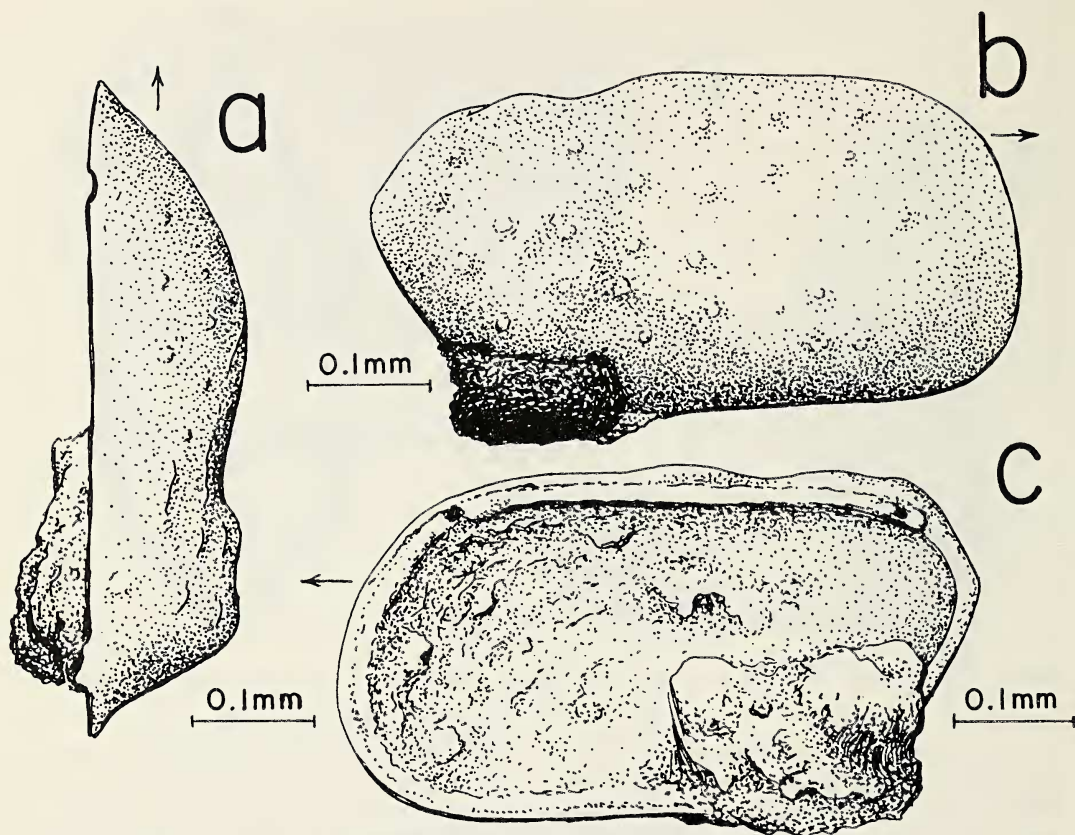


FIG. 22. *Loxoconcha* sp. a-c, Specimen USNM 648775; a, dorsal view of right valve showing postero-lateral sulcus; b, lateral view showing pustulose surface,  $MnO_2$  obscuring posteroventral area; c, internal view.

*Loxoconcha longispina* Keij, 1953

Figs. 23 a-d

*Loxoconcha alata* Brady, 1880. Rept. Voyage Challenger, Zool. 1, pt. 3, p. 122, pl. 27, figs. 6 a-j.

*Loxoconcha alata longispina* Keij, 1953. Koninkl. Nederl. Akad. van Wetenschappen, Amsterdam, ser. B, vol. 56, pt. 2, p. 160, pl. 1.

**DIAGNOSIS:** Short rhomboidal carapace; well-developed ventral tubercle; faint central sulcus; pronounced reticulate ornamentation.

**DESCRIPTION:** In lateral view: carapace short, rhomboidal; dorsal margin straight, parallel to straight ventral margin; anterior margin evenly rounded but flattened in anterodorsum; pointed caudal process in upper half of posterior margin; broad subcentral tubercle and faint post-adjacent median sulcus present; large pointed tuberculate alae ventrally extended; broad posterodorsal enlargement sometimes developed.

Eye tubercles large; ornamentation of deep reticulations, elongate on ventral knob, small on subcentral tubercle. In dorsal view: carapace much wider than high due to massive posteriorly pointing knobs; posterior laterally compressed.

Hingement gonglyodont: anterior element of right valve a rounded socket with postadjacent round tooth and small socket; sockets connected above tooth; median element a crenulate groove, coarser at ends; posterior element a large projecting reniform tooth; strong accommodation groove above median element of left valve.

Adductor muscle scar pattern a row of four smaller equant scars on side of pit; large single antennal scar anterior to top two adductor scars; large conspicuous mandibular scar dorsal to adductor group on median ridge. Continuous flange and large groove around anterior-ventral-posterior duplicature of right valve; left valve with corresponding well developed selvage.

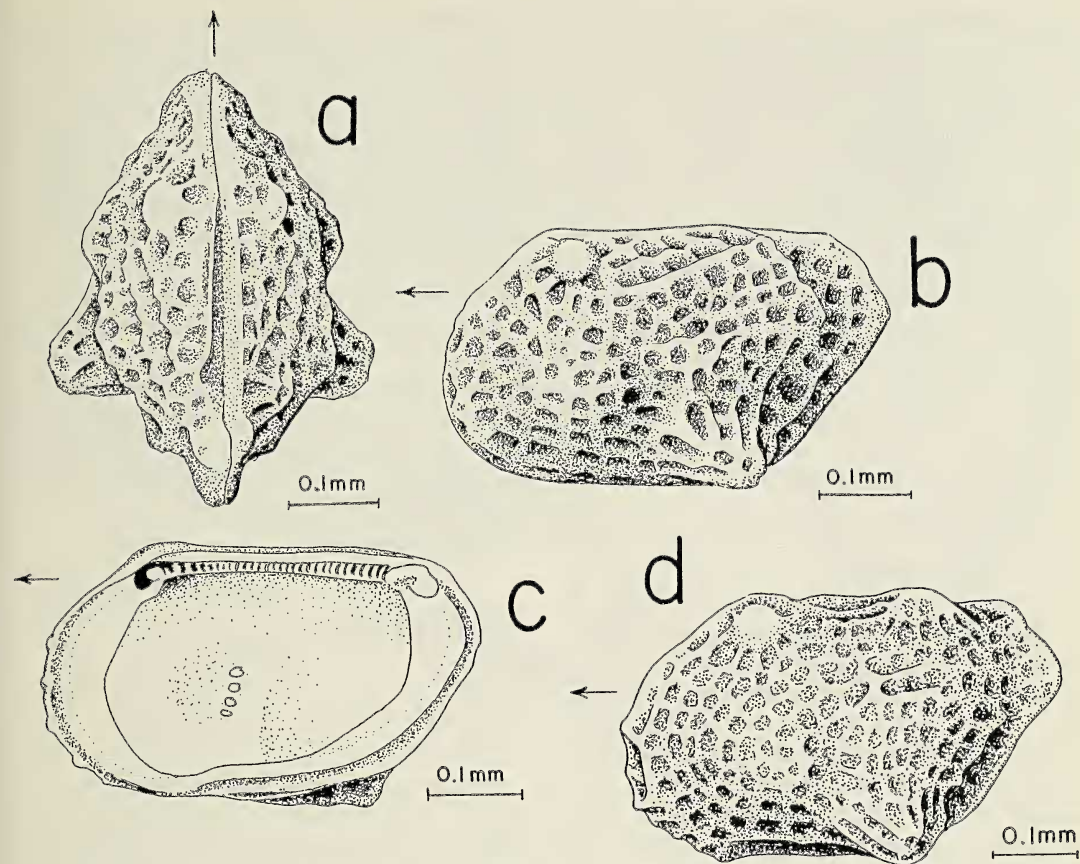


FIG. 23. *Loxoconcha longispina* Keij, 1953. *a-b*, Plesiotype USNM 648776; *a*, dorsal view of entire carapace; *b*, lateral left valve view. *c*, Plesiotype SDNH 1052; internal view of right valve, marginal features not preserved. *d*, Plesiotype USNM 648777; lateral left valve view of dorsally tuberculate form.

DIMENSIONS: See Table 7.  
DISTRIBUTION: As fossils from T-1 (2 valves), T-11 (2 valves; 1 entire), and T-12 (105 valves; 6 entire); Recent from the Hawaiian Islands at T-13 (2 valves), Easter Island at EA-1 (3 valves); reported by Brady (1880) off Honolulu at 40 fathoms, and by Brady

(1890) from New Caledonia at 3–6 fathoms and Fiji in the littoral zone; reported by Keij (1953) from 364–4483 m (redeposited) in the Banda, Java, and Celebes seas.  
DISCUSSION: *Loxoconcha longispina* occurs in great abundance at T-12, but is strangely absent from most other stations from the drowned ter-

TABLE 7  
DIMENSIONS OF *Loxoconcha longispina* KEIJ, 1953

SPECIMEN	LENGTH	WIDTH	HEIGHT
Plesiotype USNM 648776 (entire) T-12	0.53	0.38	0.32
Plesiotype USNM 648777 (right valve) T-12	0.54	0.24	0.34
Plesiotype USNM 648778 (right valve) T-12	0.50	0.19	0.30
Plesiotype USNM 648779 (entire) T-12	0.54	0.39	0.32
Plesiotype SDNH 1052 (right valve) T-12	0.51	0.21	0.30
Plesiotype SDNH 1053 (left valve) T-12	0.53	0.21	0.32
Plesiotype SDNH 1054 (right valve) T-12	0.52	0.20	0.32



rates. Brady's living specimens of *L. alata* off Honolulu are much smaller (length 0.44 mm) than those dealt with here, and his figures do not show the slight median compression. Adult Recent specimens from T-13, however, are comparable to Brady's form except that they are the same size as the fossil form, i.e., 0.52 mm long. The Recent form has more winglike alae with a more posteriorly pointing trend. Sexual dimorphism with thinner males(?), as noted by Brady, does not occur in the present specimens. Both fossil and Recent forms possess a slight enlargement in the posterodorsum resembling *Loxocorniculum* (Benson and Coleman, 1963); however, this enlargement does not always occur in the fossils.

Some confusion exists between the type species of *Loxoconcha alata* Brady, 1868b, from the Mediterranean, and forms similar to the present species. The original description of *L. alata* shows an elongate, finely and concentrically pitted carapace with pointed alae. In dorsal view it is more anteriorly acuminate. Keij's identification of *L. alata* (Keij, 1953: 160) is probably based on Brady's (1880) misidentification, as was Fyan's (1916), even though Brady (1886) expressed doubts about his earlier identification when he stated that the specimens comprising the species *L. alata* Brady, 1880 "are, I think, identical to" *L. gibbera* from Ceylon. They probably are not, and there appear to be several species of alate loxoconchids from the Mediterranean, Indian, and Pacific regions. Other papers reporting, but not describing, "*L. alata* Brady," are by Brady (1886, 1890), Chapman (1902), Scott (1905), and Bold (1946b).

#### Genus *Loxoconchella* Triebel, 1954

*Loxoconchella honoluliensis* (Brady), 1880  
Figs. 24 a-c

*Loxoconcha honoluliensis* Brady, 1880. Rept. Voyage Challenger, Zool. 1, pt. 3, p. 118, pl. 28, figs. 6 a-f.

*Loxoconchella honoluliensis* (G. S. Brady) Triebel, 1954. Senckenbergiana 35, p. 19, pl. 1, figs. 1-6.

DIAGNOSIS: Evenly inflated punctate carapace; prominent posteroventral keel; and lenticular shape in dorsal view.

DESCRIPTION: In lateral view: greatest carapace height in posterior half; dorsal margin straight between high eye tubercle and concave posterodorsum; anterior margin evenly and broadly rounded; ventral margin straight in anterior half; caudal process distinct, at mid-height; surface finely punctate (not illustrated). In dorsal view: carapace lenticular; greatest width at midlength; posterior compressed; left valve overlapping right valve in posterior third.

Hinge adont: bar of left valve a continuation of anterior margin along dorsum to posterodorsal cardinal angle, with well-developed centrodorsal accommodation groove; posterior element a distinct groove from posterodorsal cardinal angle to base of caudal process. Other internal features not preserved.

#### DIMENSIONS:

	PLESIOTYPE	LENGTH	HEIGHT	WIDTH
USNM 648780				
(entire ♀) T-4		0.67	0.47	0.34
SDNH 1055				
(entire ♂) T-13		0.52	0.36	0.25
SDNH 1056				
(right valve ♀) T-4		0.65	0.46	0.17

DISTRIBUTION: As fossils from T-1 (2 valves), T-4 (1 valve; 1 entire), and T-7 (6 valves; 2 entire); found living in the Hawaiian Islands at T-13 (1 valve; 1 entire) and Easter Island at EA-1 (2 valves). Reported living by Brady (1880) off reefs at Honolulu at 40 fathoms, and by Brady (1890) at New Caledonia at 2-6 fathoms, and at Fiji and Samoa in the littoral zone.

DISCUSSION: Variation in the development of reticulations occurs in the present specimens, with a few individuals from T-7 being ornamented somewhat like *Loxoconchella anomala*. However, the reticulations on *L. honoluliensis* are never as deep as on *L. anomala*.

Following Brady (1880:117), the compressed form is considered to be the male. This expression of sexual dimorphism is uncommon in the family Loxoconchinae, where the males are usually longer than the females.

*Loxoconchella anomala* (Brady), 1880  
Figs. 25 a-f

*Loxoconcha anomala* Brady, 1880. Rept. Voyage Challenger, Zool. 1, pt. 3, p. 123, pl. 28, figs. 5 a-d.



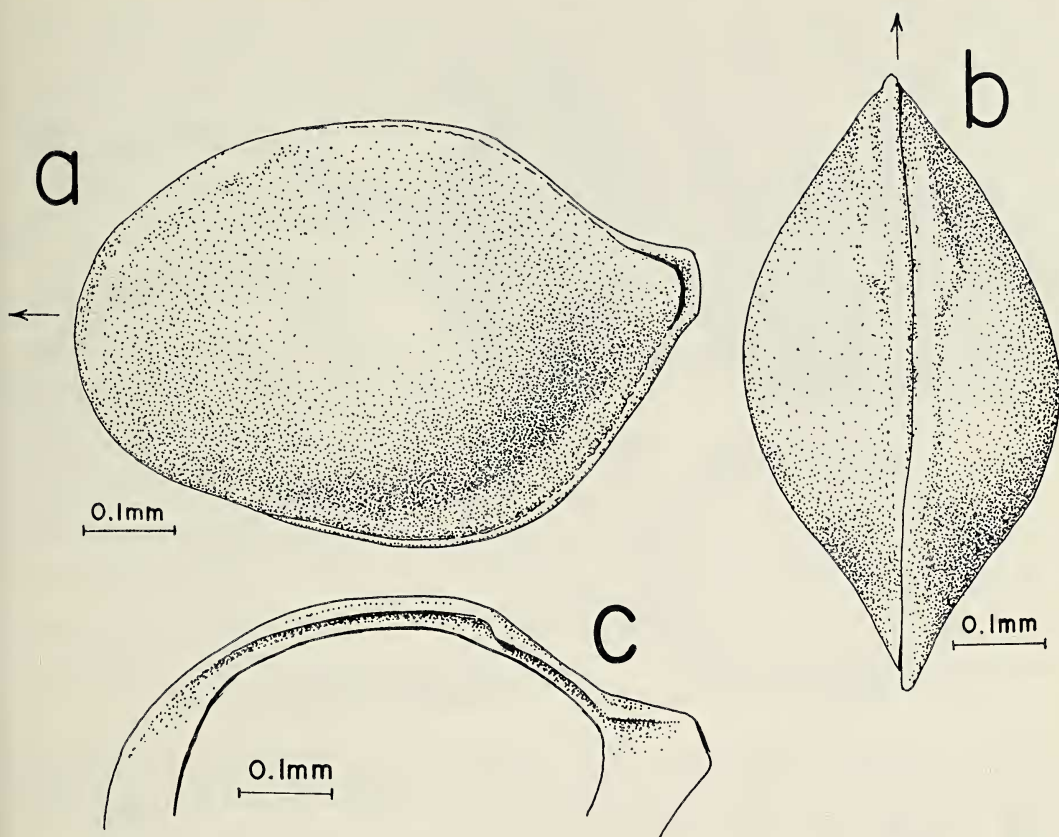


FIG. 24. *Loxoconchella bonoluliensis* (Brady), 1880. *a-b*, Plesiotype USNM 648780; *a*, left valve view of slightly deformed entire female carapace; *b*, dorsal view. *c*, Plesiotype SDNH 1056; hinge view of right valve.

**DIAGNOSIS:** Heavily reticulate, posterodorsally inflated carapace; broad caudal process; relatively simple radial pore canals.

**DESCRIPTION:** In lateral view: dorsal margin straight from large low-set eye tubercle to highest point just behind carapace midlength, then concave upward to end of high, large caudal process; ventral margin gently and evenly rounded, continuous with evenly rounded anterior margin; posterior margin below caudal process very slightly concave; surface heavily reticulate except on smooth caudal process, reticulations forming concentric pattern; weak marginal ridge from eye tubercle to postero-venter around anterior margin. In dorsal view: carapace diamond shaped, widest just behind center at subtle knoblike posterodorsolateral inflations. Dimorphism of narrow males(?) and wide females(?).

Hinge adont: anterior element of right valve

a short groove with ventroadjacent short bar, groove continuous with median element of a straight smooth furrow; posterior element a long straight smooth bar; accommodation groove above median element of left valve. Adductor muscle scar pattern of four small elongate scars in curved row, top scar larger and apart from other three; larger single antennal scar anterior to top adductor scar. Duplication wide, anterior and posteroventral vestibules present; radial pore canals long, dividing into three near margin, variable, some widened, as elongate extensions of the vestibule; normal pores small, several to each reticulation, interior surface unpitted.

**DIMENSIONS:** See Table 8.

**DISTRIBUTION:** As fossils from T-1 (1 valve), T-4 (1 valve; 1 entire), T-7 (2 valves), T-11 (1 valve; 1 entire), and T-12 (19 valves; 4 entire), and S-23 (1 valve). Reported by Brady

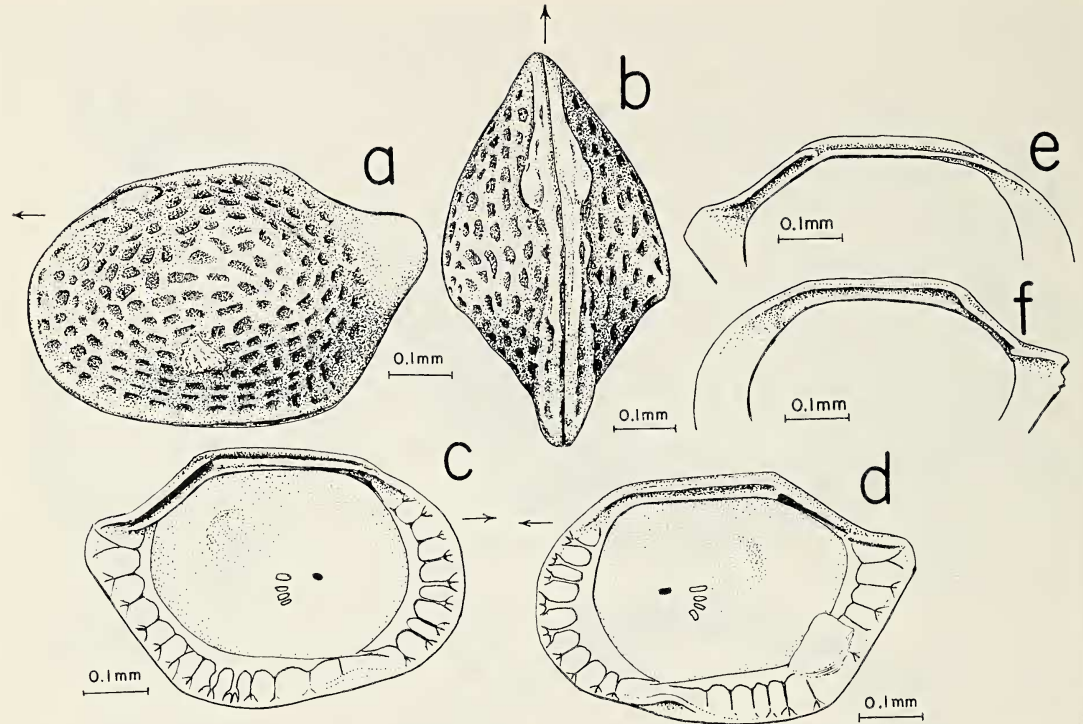


FIG. 25. *Loxoconchella anomala* (Brady), 1880. *a*, Plesiotype USNM 648781; side view of male left valve. *b*, Plesiotype SDNH 1057; dorsal view of entire male carapace. *c*, Plesiotype USNM 648782; internal view of left valve. *d*, Plesiotype SDNH 1058; internal view of right valve. *e*, Plesiotype USNM 648793; hinge view of left valve. *f*, Plesiotype SDNH 1059; hinge view of right valve.

(1880) off reefs at Honolulu, Hawaii at 40 fathoms, and by Brady (1890) at New Caledonia at 3–6 fathoms and Fiji in the littoral zone.

DISCUSSION: *Loxoconchella anomala* differs from the type species, *L. bonoluliensis*, by having less complex vestibules and large dorso-lateral inflations, especially well developed in the wider form. Of lesser importance between the two species, *L. anomala* is deeply reticulate

whereas *L. bonoluliensis* is punctate to lightly reticulate.

Family PARADOXOSTROMATIDAE  
Brady and Norman, 1889  
Genus *Paradoxostoma* Fischer, 1855

*Paradoxostoma* sp. A  
Figs. 26 *a–b*

DESCRIPTION: In lateral view: carapace anteriorly acuminate; venter slightly concave;

TABLE 8  
DIMENSIONS OF *Loxoconchella anomala* (BRADY), 1880

SPECIMEN	LENGTH	WIDTH	HEIGHT
Plesiotype USNM 648781 (left valve ♂) T-12	0.63	0.19	0.42
Plesiotype USNM 648782 (left valve ♂) T-12	0.59	0.18	0.40
Plesiotype USNM 648783 (entire ♀) T-12	0.63	0.38	0.45
Plesiotype USNM 648793 (left valve ♀) T-12	0.64	0.23	0.45
Plesiotype SDNH 1057 (entire ♂) T-12	0.62	0.33	0.40
Plesiotype SDNH 1058 (right valve ♂) T-12	0.59	0.17	0.40
Plesiotype SDNH 1059 (right valve ♂) T-12	0.60	0.18	0.41

anterior bluntly pointed at midheight; dorsum angled, with posterior and anterior sloping parts; greatest height in posterior half; surface smooth. In dorsal view: carapace compressed; terminally acuminate; greatest width at midlength.

**DIMENSIONS:** Specimen USNM 648784 (entire T-12: length, 0.53; width, 0.14; height, 0.25.

**DISTRIBUTION:** As fossil from T-12 (1 entire).

**DISCUSSION.** In general shape the present species approaches *Paradoxostoma complanatus* (Brady), 1880, from Kerguelen Island, South Indian Ocean. Both species possess a bluntly pointed caudal process, low height, and small, somewhat pointed anterior margin. But the Hawaiian species is more anteriorly inflated, has a concave venter, and is smaller.

*Paradoxostoma* sp. B

Figs. 27 a-b

**DESCRIPTION:** Carapace smooth, elongate. In

lateral view: ventral and dorsal margins subparallel, converging slightly toward anterior; dorsal margin almost straight, gently convex; ventral margin straight at midlength, curving up posteriorly beneath poorly developed high caudal process, curving up more gradually anteriorly to a blunt anterior margin. In dorsal view: carapace terminally acuminate, greatest width at middle; posterior sharply acuminate; anterior somewhat blunt. Duplicature wide, with greatest width posteroventral.

**DIMENSIONS:** Specimen USNM 648785 (left valve) T-12: length, 0.69; width, 0.08; height, 0.27.

**DISTRIBUTION:** As fossil from T-12 (1 valve).

**DISCUSSION:** The unusually straight dorsum and apparent lack of dentition are not characteristic of the genus *Paradoxostoma*, although the high caudal process and anteriorly narrowing carapace are.

The collection consists of a single left valve in poor condition from station T-12.

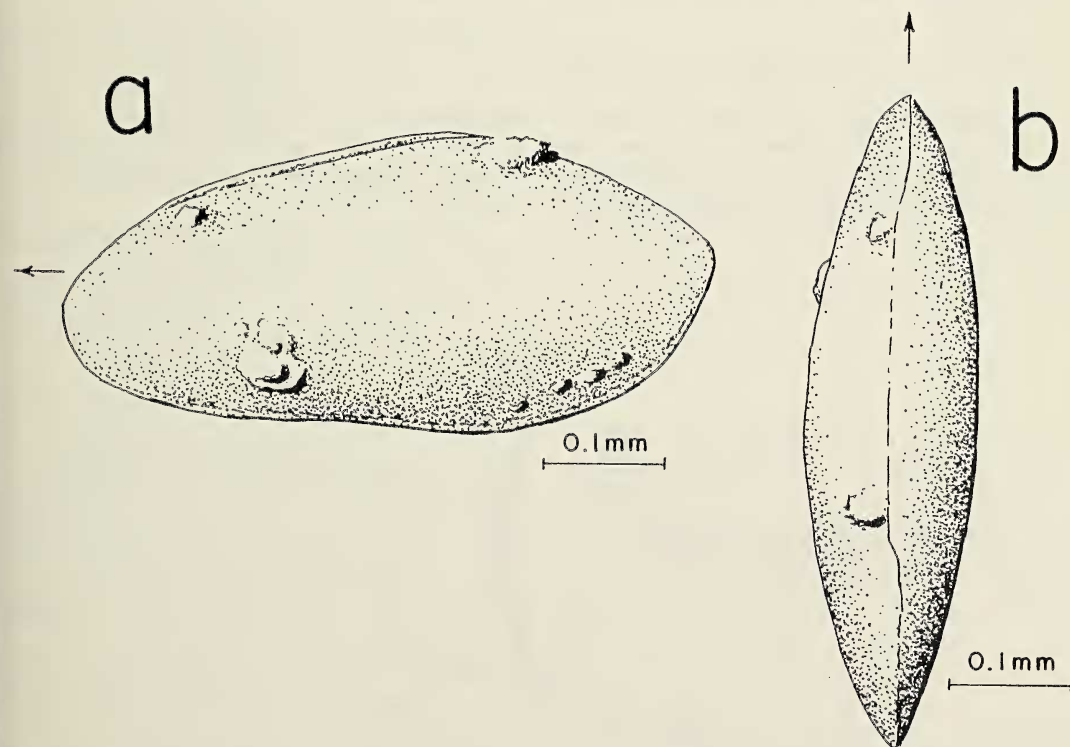


FIG. 26. *Paradoxostoma* sp. A. a-b, Specimen USNM 648784; a, left valve lateral view showing overlap of right valve; b, dorsal view.



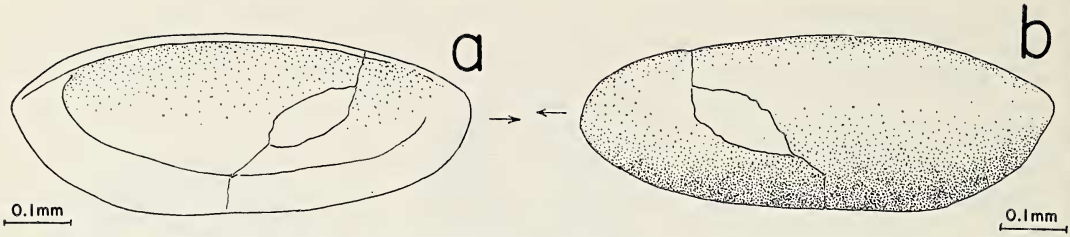


FIG. 27. *Paradoxostoma* sp. B. *a-b*, Specimen USNM 648785; *a*, internal view of broken left valve; *b*, exterior view.

*Paradoxostoma* cf. *P. rubrum* G. W. Müller, 1894

Figs. 28 *a-c*

DESCRIPTION: In lateral view: carapace narrow; dorsum broadly arched; greatest height just behind midlength; venter slightly concave; anterior somewhat pointed; posterior with narrow caudal process; surface smooth; in dorsal view: posteriorly pointed, less pointed anteriorly; greatest width midlength. Duplicature wide, especially in anterior.

DIMENSIONS: Specimen USNM 648786 (broken right valve) T-4: length, 0.58; width, 0.07; height, 0.18.

DISTRIBUTION: As fossil from T-4 (1 valve). *Paradoxostoma rubrum* Müller, 1894 occurs with calcareous algae in the bay of Naples.

DISCUSSION: The extremely thin, low carapace with duplicature suggests that the species belongs in the family Paradoxostomatidae. Though placed in the genus *Paradoxostoma*,

following Müller (1894), the present specimen, together with *P. rubrum* Müller, may warrant new generic status.

The fossil specimen from Hawaii is comparable, but not conspecific, with *Paradoxostoma rubrum* Müller, 1894 from the Gulf of Naples, Italy. These two forms are certainly closely related and differ only in details of shape.

Genus *Sclerochilus* Sars, 1866

*Sclerochilus* sp. A

Figs. 29 *a-b*

DESCRIPTION: In lateral view: shell elongate, length  $2\frac{1}{2}$  times the height; dorsum broadly and evenly rounded; anterior abruptly rounded, subtruncate; anteroventer concave, postero-venter slightly convex; surface completely smooth. Internal features not preserved; hinge apparently adont.

DIMENSIONS: Specimen USNM 648787 (left

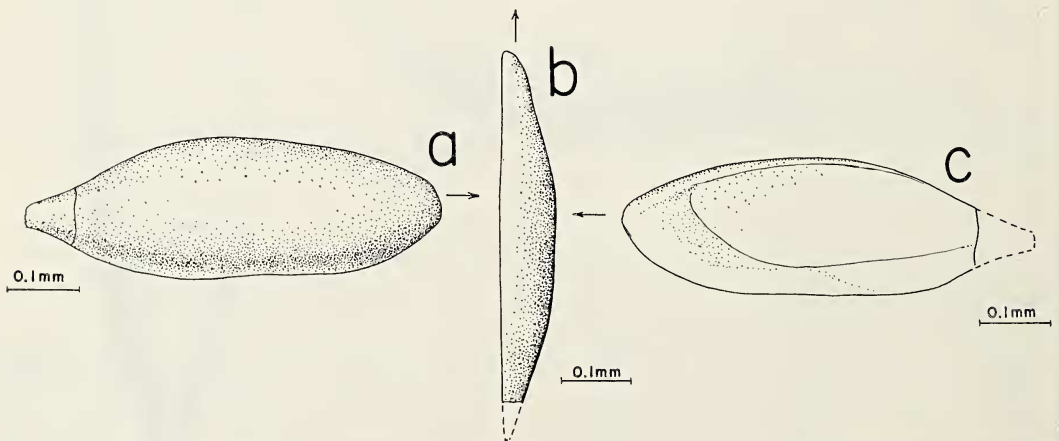


FIG. 28. *Paradoxostoma* cf. *P. rubrum* G. W. Müller, 1894. *a-c*, Specimen USNM 648786; *a*, side view of right valve; *b*, dorsal view; caudal process broken; *c*, internal view showing wide anterior duplicature.

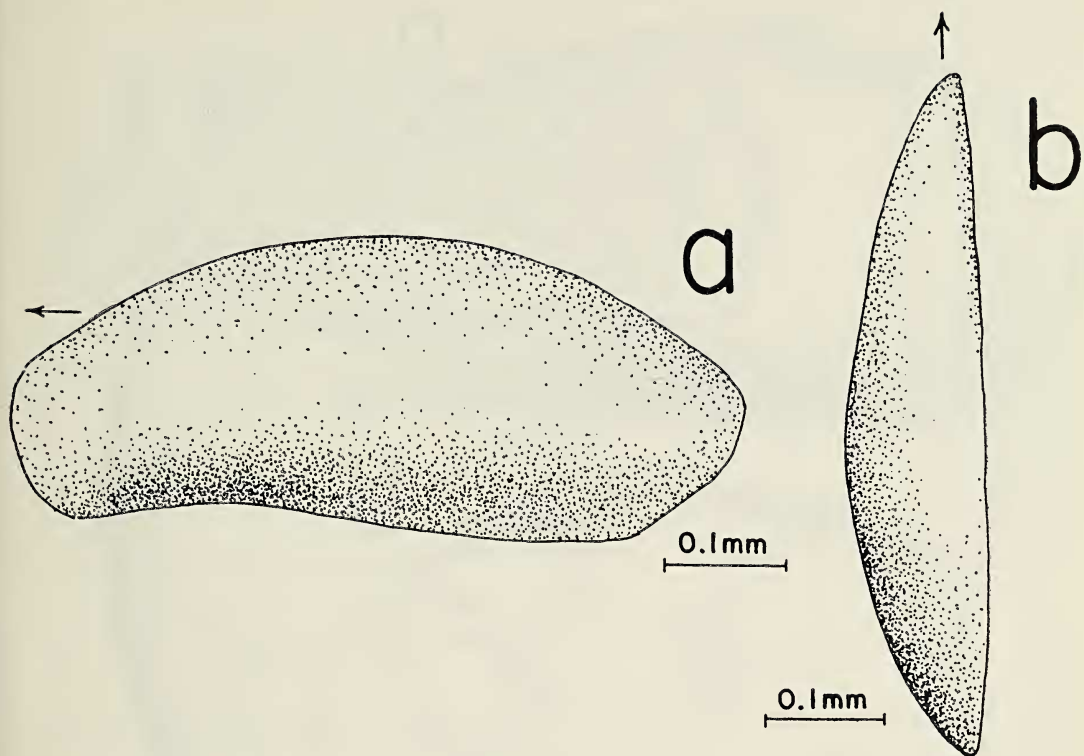


FIG. 29. *Sclerochilus* sp. A. a-b, Specimen USNM 648787; a, lateral view of left valve; b, dorsal view.

valve) T-12: length, 0.61; width, 0.10; height, 0.26.

DISTRIBUTION: As fossil from T-12 (1 valve).

DISCUSSION: Only one specimen of this species was collected at station T-12. The interior of the specimen is heavily encrusted, and so most certainly it belongs to the fossil suite.

*Sclerochilus* sp. B.  
Figs. 30 a-c

DESCRIPTION: In lateral view: subovate; dorsal margin broadly rounded; anterior and posterior margins equally rounded; ventral margin gently convex in posterior half, sharply concave in anterior half; greatest valve height central; length not quite twice the height; surface smooth. In dorsal view: greatest width central; length  $2\frac{1}{2}$  times the width; posterior half somewhat more inflated than anterior half.

Hinge weak: right valve apparently overlapping left valve at dorsal extremities; faint groove in right valve to receive dorsal edge of

left valve. Duplicature of even width. Adductor muscle scar pattern of five elongate scars subcentrally located, all apparently divided; two oblique mandibular scars near venter above inturned area.

DIMENSIONS: Specimen USNM 648788 (right valve) T-12: length, 0.46; width, 0.10; height, 0.25.

DISTRIBUTION: As fossil from T-12 (1 valve).

DISCUSSION: The Hawaiian species bears some affinity to *Sclerochilus contortus* (Norman), 1862 of Brady, 1880 from the Recent of Kerguelen Island, southern Indian Ocean, and from Head Island, New Zealand. The two species differ only in that the former is relatively higher. Brady's forms, in turn, differ considerably from Norman's illustrations by being shorter and with more evenly rounded ends.

The single right valve dealt with here is poorly preserved. The adductor muscle scar pattern appears to be divided; however, this cannot be said with certainty.

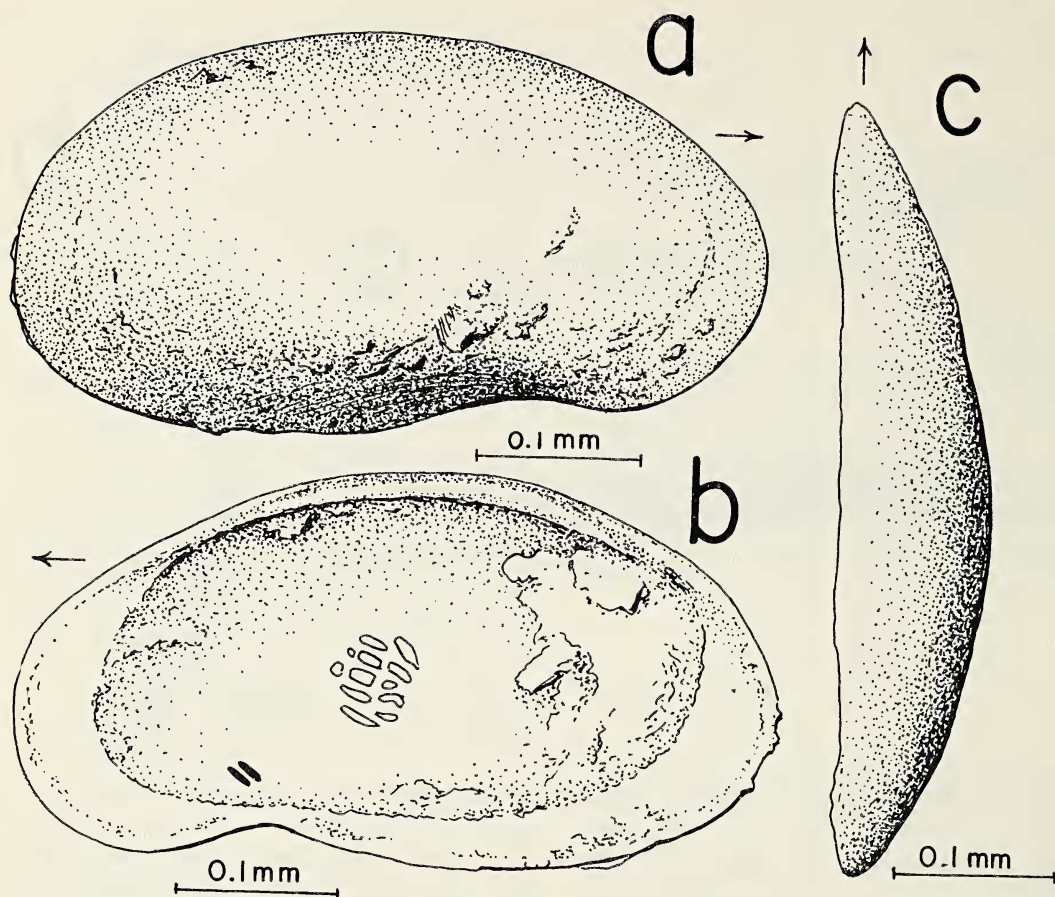


FIG. 30. *Sclerochilus* sp. B. *a-c*, Specimen USNM 648788; *a*, lateral view of right valve; *b*, internal view; muscle scar pattern poorly preserved; *c*, dorsal view.

Family TRACHYLEBERIDIDAE,  
Sylvester-Bradley, 1948

Genus *Cletocythereis* Swain, 1963

*Cletocythereis bradyi* n. sp.

Figs. 31 *a-c*

*Cythere rostromarginata* Brady, 1880 [*partim*]. Rept. Voyage *Challenger*, Zool. 1, pt. 3, p. 83, pl. 16, figs. 2 *a-d*.

DESCRIPTION: In lateral view: carapace sub-rectangular; anterior margin bluntly, evenly rounded, denticulate; dorsal and ventral margins fairly straight, parallel; posterior margin concave in upper part, convex in lower part, forming point at midheight; five massive contorted spines in posteroventer; sexual dimor-

phism conspicuous, with longer males; small subdued subcentral tubercle and low conspicuous eye tubercles present; surface with large deep cloverleaf-shaped, flat-bottomed reticulations, widening inwardly, bounded by flat-topped ridges; anterior rim lined with closely packed, small, elongate, deep reticulations; lateral surface flat. In dorsal view: carapace arrow-shaped due to winglike extensions of ventral ridges.

Hinge holamphidont: right valve with heavy projecting anterior tooth, posteroadjacent entire socket, very finely crenulate groove (not illustrated in Fig. 31*b*) and entire faintly trilobed posterior tooth. Duplicature moderately wide; vestibules not present; continuous selvage from anterior tooth of right valve around venter to pointed posterior; muscle scars not observed.



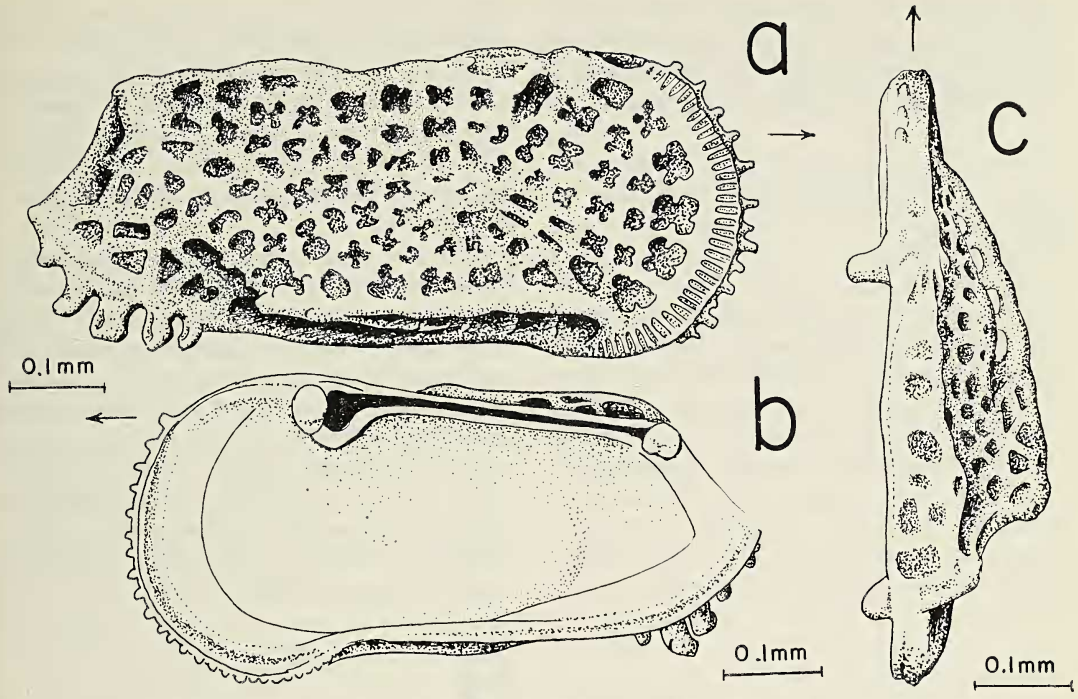


FIG. 31. *Cletocythereis bradyi* n. sp. a, Holotype USNM 648789; side view of male right valve. b-c, Paratype SDNH 1060; b, internal view of female right valve; c, dorsal view.

DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648789 (right valve ♂) T-12	0.80	0.20	0.36
Paratype SDNH 1060 (right valve ♀) T-12	0.70	0.18	0.35
Paratype USNM 648790 (entire ♂) T-12	0.76	0.35	0.36
Paratype USNM 648791 (entire ♀) T-12	0.69	0.36	0.35
Paratype SDNH 1061 (young right valve) T-12	0.63	0.19	0.30

DISTRIBUTION: As fossils from T-12 (13 valves; 4 entire) and Easter Island at EA-2 (4 valves; 9 entire). Reported by Brady, *partim* "females" (1880:83) at 39° 32' S, 171° 48' E (station 167).

DISCUSSION: Swain (1963) designated *Cythere rastromarginata* Brady, 1880 the type species of his new genus *Cletocythereis*, which, together with *C. noblissimus* Swain, 1963, from the Pleistocene Gubick Formation of Alaska, comprise the only known species of the genus. *C. noblissimus*, however, with its ornamenta-

tion of three lateral rows of spines and other differences, most probably belongs to another genus. *Cletocythereis*, to date, is monotypic.

The fossil specimens from the Hawaiian Islands are comparable in part with *Cythere rastromarginata* Brady, 1880. Brady has mistakenly equated an alate form with a compressed form, believing these differences to be caused by sexual dimorphism. Brady's inflated form (1880:pl. 16, fig. 2) and the fossils from the Hawaiian Islands are included together in the new species; his description of *Cythere rastromarginata* is obviously based on the nonalate form and it should retain the name. The present species is distinctly alate and exhibits typical trachyleberid dimorphism, with longer males. It may be significant that Brady's "males" are not reported from the same locality as his "females," but it is strange that the former were reported from the Hawaiian Islands and the latter from New Zealand.

*Hermanites paijenborchiana* Keij, 1957 from the Eocene of France appears to be closely related to *Cletocythereis bradyi*, differing only in

the possession of a dorsal ridge, slightly shorter carapace, and absence of ornamentation on the anteromarginal ridge. Both species show deep reticulations with secondary intergrowths.

Genus *Hermanites* Puri, 1955

*Hermanites* sp.

Figs. 32 a-c

DESCRIPTION: In lateral view: carapace almost quadrate; dorsal margin straight, with weakly bifurcating, crooked marginal ridge; anterior margin heavily rimmed, obliquely rounded, ventrally extended; ventral straight, subparallel with dorsal margin; posteroventer with short spines; ventrolateral alae straight, horizontal, projecting posteriorly about  $23^\circ$  from shell; ornamentation of well-developed reticulations in a pattern concentric around

large smooth subcentral tubercle; eye tubercle very large. In dorsal view: anterior blunt, with inner row of small denticles extending around entire anterior margin; posterior compressed; shell strongly projecting at subcentral tubercle, posterior part of ventrolateral ridge, and posterodorsal tubercle; carapace widest at subcentral tubercle.

Adductor muscle scars on side of deep subcentral depression; top two scars divided, elongate, oblique; two lower scars almost fused; two antennal scars on anterior side of pit; four small antennal scars on bottom of pit with large anteriorly opened V-shaped scar behind. Radial pore canals abundant, about 45 in anterior, many with elongate sinuous midswellings, coinciding with marginal denticles; normal pores sparse, not necessarily coinciding with exterior reticulations; anterior duplicature moderately wide, without vestibules.

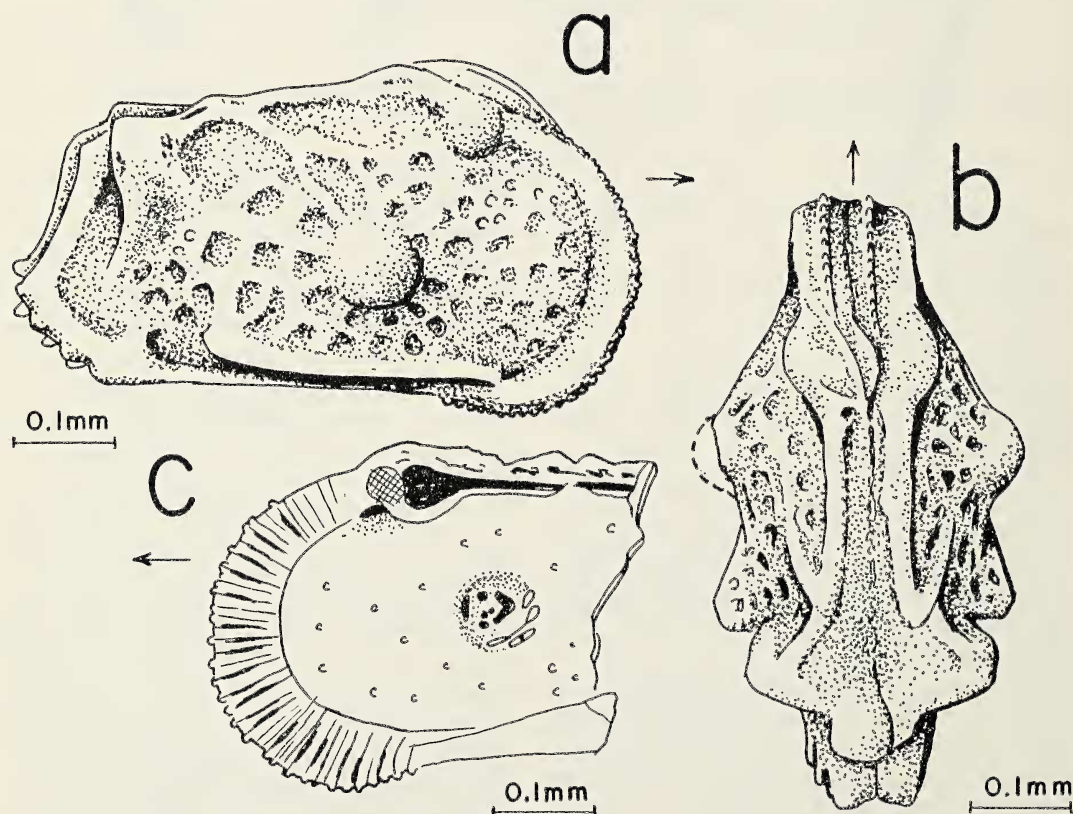


FIG. 32. *Hermanites* sp. a-b, Specimen USNM 648792; a, right valve view of entire carapace; b, dorsal view showing tri-tuberculate carapace. c, SDNH 1062; internal view of broken right valve; adductor scars in white.



DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
USNM 648792 (entire) T-7	0.59	0.31	0.35
SDNH 1062 (broken right valve) T-7	—	0.15	0.33

DISTRIBUTION: As fossils from T-7 (2 valves; 1 entire).

DISCUSSION: This species is placed in the genus *Hermanites* on the basis of morphology and ornamentation. Conversely, the internal features are unlike other species previously assigned to this genus: an excessive number of muscle scars, i.e., 6–7 antennal and 6–7 adductor scars, occurs in the present species, where typically only one antennal and four mandibular scars should be present.

Excessively divided adductor scars suggest the family Hemicytheridae; however, the radial pore canals, though abundant and with midswellings, are not as abundant as in the hemicytherids and the midswellings are irregular.

The only trachyleberid genus having excessive muscle scars is the Lower Cretaceous *Isochthereis* (Sylvester-Bradley in Moore, 1961: Q340); however, the present species does not otherwise resemble species of that genus.

*Neocaudites terryi* n. sp.

Figs. 33 a–d

DIAGNOSIS: A smooth carapace; moderate size; small knob on posterior ventrolateral surface.

DESCRIPTION: In lateral view: length about 2.1 times the height (males) to about 1.9 times the height (females); ventral margin slightly concave, curving upward at posteroventer with five or less short heavy spines; anterior margin finely denticulate, flattened in dorsal half; dorsal margin straight, sloping backward behind highest point of carapace just anterior to poorly developed eye tubercle; posterior margin truncate; left valve slightly larger and strongly overlapping right valve above eye tubercle; strong continuous marginal ridge present, angling ventrally in posterodorsal area, forming oblique lateral ridge ending at indistinct subcentral tubercle; short arcuate ridge on lateral surface just posterior to, and paralleling, anterior margin; surface smooth with faint reticulations bordering ridges and above subcentral tubercle; small pronounced knob on posterior part of ventrolateral surface. In dorsal view: carapace laterally compressed; length three times the width in both sexes; greatest inflation along

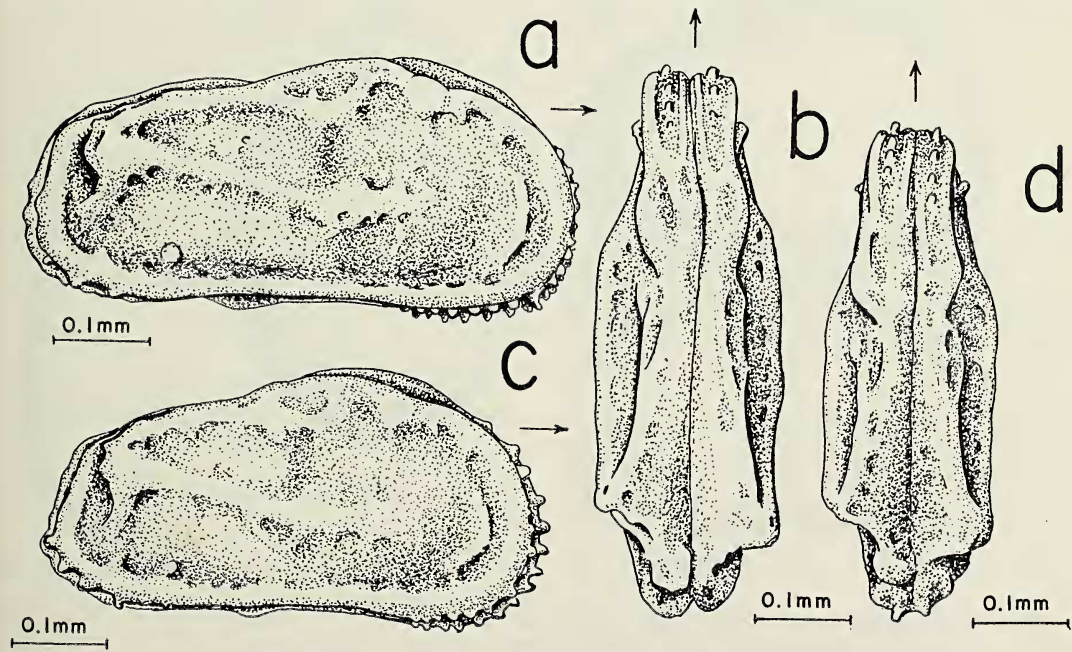


FIG. 33. *Neocaudites terryi* n. sp. a–b, Holotype USNM 648756; a, right valve side view of entire male carapace; b, dorsal view, Paratype SDNH 1063; c, right valve side view of entire female carapace; d, dorsal view.



median ridge; anterolateral and posterior areas compressed; valves unequal, posterodorsal rib juncture more posterior in right valve.

Hinge holamphidont: posterior tooth of right valve rounded, heavy; anterior tooth and postjacent socket large, median groove smooth. Radial pore canals abundant, muscle scars and other internal features obliterated.

#### DIMENSIONS:

SPECIMEN	LENGTH	WIDTH	HEIGHT
Holotype USNM 648756 (entire ♂) T-12	0.58	0.19	0.28
Paratype SDNH 1063 (entire ♀) T-12	0.53	0.17	0.28
Paratype USNM 648757 (left valve ♂) T-12	0.57	0.12	0.28

DISTRIBUTION: As fossils from T-12 (7 valves; 3 entire).

DISCUSSION: Penultimate instars of *N. terryi* are densely pitted (a finer pattern than on *N. reticulata*) and have a merodont hinge.

Named in honor of D. Terry, of North American Aviation Corporation, who collected samples T-1 through T-13.

Family XESTOLEBERIDIDAE Sars, 1928

Genus *Xestoleberis* Sars, 1866

*Xestoleberis nana* Brady, 1880

Figs. 34 a-d

*Xestoleberis nana* Brady, 1880. Rept. Voyage Challenger, Zool. 1, pt. 3, p. 126, pl. 31, figs. 3 a-c.

DIAGNOSIS: Greatly inflated carapace; flat venter; low, pointed anterior.

DESCRIPTION: Carapace almost oval in dorsal view: rounded posteriorly, slightly acuminate anteriorly. In lateral view: ventral margin long, straight; dorsal margin broadly rounded, sloping down anteriorly; left valve overlapping right valve around entire margin; surface smooth.

Hinge antimerodont: right valve with arcuate crenulate anterior bar, deep arcuate crenulate median furrow medially covered by thick dorsal ledge, and short, straight, heavily notched, posteriorly extending rear element.

Adductor muscle scar pattern large, of four irregular scars in vertical row; V-shaped anten-

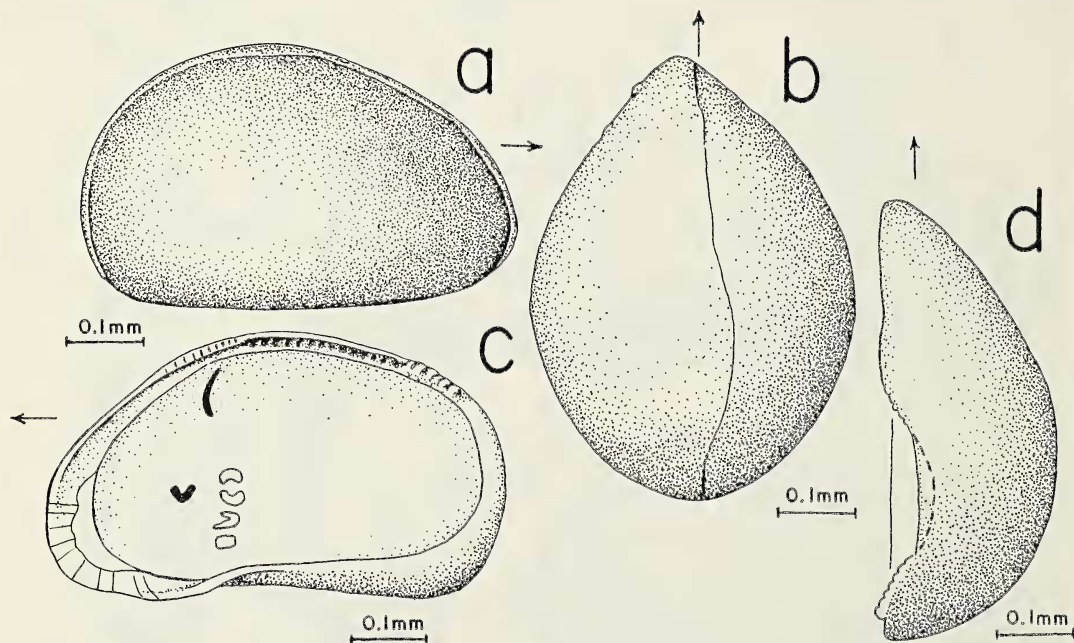


FIG. 34. *Xestoleberis nana* Brady, 1880. a-b, Plesiotype USNM 648767; a, right valve view of entire female(?) carapace showing overlap of left valve; b, dorsal view. c-d, Plesiotype SDNH 1064; c, internal view of female (?) right valve; d, dorsal view.

nal scar anterior to top two adductor scars; characteristic xestoleberid arcuate scar in anterodorsum. Deep anterior and posterior vestibules ventrally located; radial pore canals simple, normal pores small, sparse.

## DIMENSIONS:

PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648767 (entire) T-12	0.57	0.40	0.35
SDNH 1064 (right valve) T-12	0.57	0.42	0.40
USNM 648768 (entire) T-12	0.64	0.44	0.42
USNM 648769 (left valve) T-12	0.62	0.27	0.39
USNM 648770 (entire) T-12	0.57	0.38	0.35

DISTRIBUTION: As fossils from T-1 (3 valves), T-2 (4 valves), T-4 (2 valves; 1 entire), T-7 (2 valves), T-8 (3 valves), T-11 (4 valves; 3 entire), T-12 (56 valves; 3 entire), AR (2 valves; 1 entire), and S-23 (5 valves); found living from HA (1 valve) and T-13 (1 valve). Reported by Brady (1880) off Tongatabu (station 172) in the Friendly Islands.

DISCUSSION: The collection consists mostly of immature instars. Those described by Brady (1880:126) are considerably smaller (length 0.45 mm) than those dealt with here. Dr. R. H. Bate (personal communication) of the British Museum (Natural History) made comparisons of the Hawaiian specimens with Brady's types and found that *Xestoleberis nana* Brady, from the Friendly Islands, although smaller, is more similar in shape to the adult fossil specimens from the Hawaiian Islands than to their young of the same size as Brady's types.

## Suborder and family uncertain

Genus *Anchistrocheles* Brady and Norman, 1889

*Anchistrocheles fumata* Brady, 1890

Figs. 35 a-c

*Anchistrocheles fumata* Brady, 1890. Trans. Roy. Soc. Edinburgh 35, p. 497, pl. 3, figs. 13-14.

DIAGNOSIS: Anterior margin oblique, pos-

terovertrally sloping; dorsal margin nearly straight.

DESCRIPTION: Carapace smooth, laterally compressed, length about  $3\frac{1}{2}$  times the width. In lateral view: dorsal margin gently arched, almost straight; anterior margin subtruncate, sloping obliquely downward and backward; posterior margin broadly and evenly rounded; ventral margin concave at inturned area; left valve larger, overlapping right valve around all margins. In dorsal view: carapace lenticular; ends pointed. Moderate duplicature present; other internal features not preserved.

## DIMENSIONS:

PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648749 (entire) T-12	0.61	0.11	0.30
SDNH 1065 (left valve) T-12	0.59	0.08	0.31
USNM 648750 (young left valve) T-12	0.45	0.10	0.27

DISTRIBUTION: As fossils from T-12 (3 valves; 1 entire). Reported by Brady (1890) as living in shore pools at Lufi-lifi, Samoa.

DISCUSSION: In every respect, the individuals from T-12 resemble those of Brady (1890: 497) from Samoa. The species was reported by Brady from only one location in the intertidal zone, but whether it is exclusively restricted to that zone is unknown.

## Genus uncertain

"*Cythere*" *caudata* Brady, 1890

Figs. 36 a-f

*Cythere caudata* Brady, 1890. Trans. Roy. Soc. Edinburgh 35, p. 497.

*Cythere? caudata* Brady. Keij, 1954, Koninkl. Nederl. Acad. van Wetenschappen, Amsterdam, Ser. B., vol. 57, pt. 3, p. 362, pl. 3, fig. 1.

DESCRIPTION: In lateral view: carapace small (length of adult male(?) 0.41 mm), densely ornamented with oblong reticulations, whose long axes generally coincide with that of carapace length; dorsal margin straight; anterior margin dorsally flattened; ventral margin gently concave; posterior with a low, pointed, unornamented, laterally compressed caudal process; broad unornamented eye spot beneath anterior

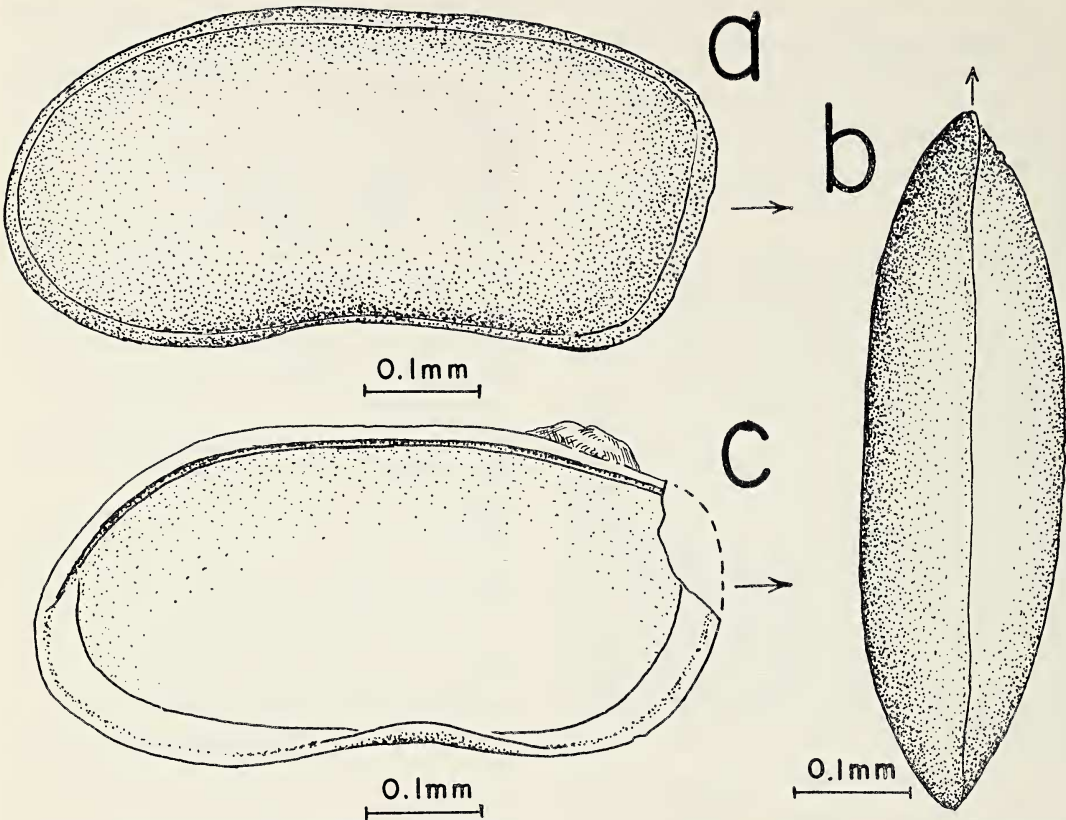


FIG. 35. *Anchistrocheles fumata* Brady, 1890. *a-b*, Plesiotype USNM 648749; *a*, right valve view of entire carapace showing overlap of left valve; *b*, dorsal view. *c*, Paratype SDNH 1065; internal view of left valve.

cardinal angle; inconspicuous curved lateral ridge roughly paralleling posterior margin. In dorsal view: carapace oblong except for compressed posterior; right valve overlapping left above hinge, overlapped by left valve above caudal process.

Hinge unique, weak: small anterior tooth of left valve faintly stepped; smooth subtle median bar; posterior element of two teeth. Anterior element of right valve a small tooth beneath socket; dorsal margin extended into faint tooth which overlaps left valve anterodorsal to socket; stepped part of anterior left valve tooth fits between two anterior teeth of right valve; posterior element single tooth posterior to, and partially above, socket.

Adductor muscle scar pattern a slightly inclined vertical row of four; single antennal scar just anterior to adductor group; single mandibular scar above adductor group. Duplicature wide; anterior vestibule deep, irregular; pos-

terior vestibule apparently moderately deep; single and bifurcate radial pore canals extremely fine, with tendency to group; normal pores small, sparse, irregularly grouped, not coinciding exclusively with external pits.

DIMENSIONS:

PLESIOTYPE	LENGTH	WIDTH	HEIGHT
USNM 648754			
(right valve) HA	0.35	0.08	0.16
USNM 648754			
(left valve) HA	0.35	0.08	0.16
USNM 648755			
(entire) T-1	0.41	0.15	0.17

DISTRIBUTION: As fossil from T-1 (1 entire); Recent from HA (2 valves; 1 entire). Described by Brady (1890) from Suva Suva Bay, Fiji Islands at 4 fathoms, and from Manila Bay by Keij (1954).

DISCUSSION: This species possesses features characteristic of the family Leptocytheridae; especially of the genus *Leptocythere*, with re-



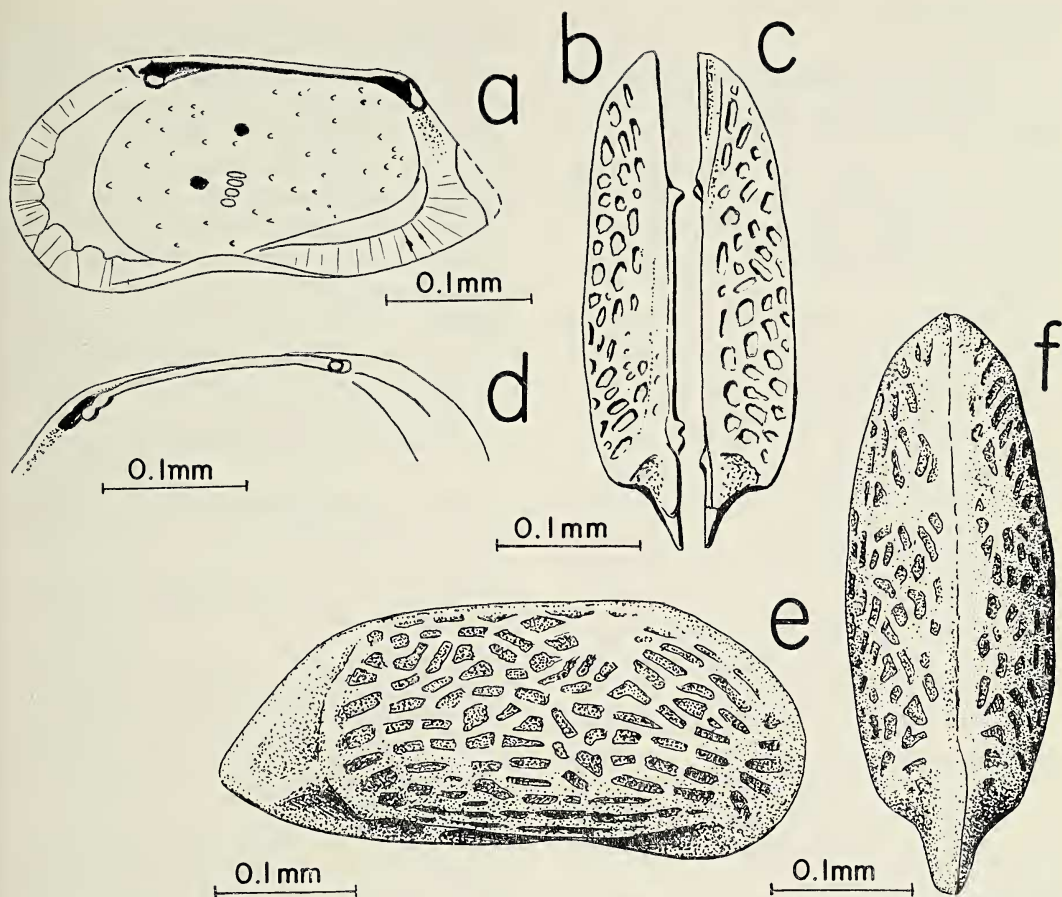


FIG. 36. "*Cythere*" *caudata* Brady, 1890. *a-d*, Plesiotype USNM 648754; *a*, internal view of broken female's(?) right valve; adductor scars in white; *b*, dorsal line drawing of left valve; *c*, dorsal line drawing of right valve; *d*, internal hinge view. *e-f*, Plesiotype USNM 648755; *e*, right valve view of entire male(?) carapace; *f*, dorsal view.

spect to its small oblong carapace and similarities in marginal areas and musculature. It lacks, however, the dentition characteristic of that family by having the median bar in the left valve instead of in the right, and by a unique tooth arrangement. Also, significant differences in the shape of the caudal process occur between "*Cythere*" *caudata* and the leptocytherids.

The fossil specimen from T-1 is longer than the living forms at HA. The long form is assumed to be the male. Hanai (1957:439) notes this type of sexual dimorphism in *Leptocythere*.

Slight differences occur in Brady's specimens from the Fiji Islands, but these do not appear to be important enough for specific differentiation. The greatest difference is size: Brady's

specimens are 0.46 mm in length, whereas the Hawaiian forms are much shorter. Also, the anterior margin of Brady's form is more evenly rounded; the anterior, in dorsal view, more acuminate. Keij's (1954) illustrations appear much like the Hawaiian specimens, with the exception of internal features.

#### REFERENCES

- ALEXANDER, C. I. 1929. Ostracoda of the Cretaceous of North Texas. Texas Univ. Bull. 2907, 137 pp., 10 pls.
- BAIRD, WM. 1845. Arrangement of the British Entomostraca, with a list of species, particularly noticing those which have as yet been discovered within the bounds of the Club.

- Berwickshire Nat. Club (Hist.) Proc. (1842-1849) 2:145-158.
- 1850. Description of several new species of Entomostraca. Zool. Soc. London, Proc., pt. 18:254-257, pls. 17-18.
- BENSON, R. H., and G. L. COLMAN. 1963. Recent marine ostracodes from the eastern Gulf of Mexico. Kansas Univ. Paleontol. Contr. 31, Arthropoda, Art. 2:1-52, 8 pls., 31 figs.
- BOLD, W. A. VAN DEN. 1946*a*. Contribution to the study of Ostracoda with special reference to the Tertiary and Cretaceous microfauna of the Caribbean region. Diss. Univ. Utrecht, Amsterdam. 167 pp., 18 pls.
- 1946*b*. Younger Neogene Quaternary and Recent Ostracoda. In: J. H. Germeraad, ed., Geology of Central Seran. Ceram. Geol., Petrog. Paleontol. Results Explorations, pt. 2. 110 pp., 13 pls.
- 1950. *Hemikrithe*, a new genus of Ostracoda from the Indopacific. Ann. Mag. Hist., ser. 12, 3(34):900-904.
- 1957. Oligo-Miocene Ostracoda from southern Trinidad. Micropaleontology 3(3):231-254, pls. 1-4, figs. 1-2.
- 1963. Anomalous hinge structure in a new species of Cytherelloidea. Micropaleontology 9(1):75-78.
- BOSQUET, J. 1852. Description des Entomostracés fossiles des terrains Tertiaires de la France et de la Belgique. Akad. Roy. Sci. Belg., Mém. Cour. et Sav. Étrang. (1850-1851) 24:142, 6 pls. (Bruxelles).
- BRADY, G. S. 1866. On new or imperfectly known species of marine Ostracoda. Zool. Soc. London. Trans. 5, pt. 5:359-391, pls. 57-62.
- 1868*a*. La mer à Noumea. In: de Folin and Périer, eds., Les fonds de la mer, 1, pt. 1, chap. 13:54-59, pl. 7 (*partim*) figs. 4-6.
- 1868*b*. Contribution to the study of the Entomostraca; no. 2, marine Ostracoda from the Mauritius. Ann. Mag. Nat. Hist., ser. 4, 2(9):178-183, pl. 4, figs. 11-14; pls. 12-13.
- 1880. Report on the Ostracoda dredged by the H.M.S. *Challenger* during the years 1873-1876. Rept. Voyage *Challenger*, Zool. 1, pt. 3:1-184, pls. 1-44.
- 1886. Notes on the Entomostraca collected by Mr. A. Haly in Ceylon. J. Linn. Soc. London, Zool. 19:293-317, pls. 37-40.
- 1890. On the Ostracoda collected by G. S. Brady in the south sea islands. Trans. Roy. Soc. Edinburgh 35:489-525, pls. 1-4.
- and A. M. NORMAN. 1889. A monograph of the marine and freshwater Ostracoda of the North Atlantic and of north-western Europe, Section 1. Podocopa. Trans. Roy. Dublin Soc. Sci., ser. 2, 4:63-270, pls. 8-23.
- CHAPMAN, F. 1902. On some Ostracoda from Funafuti. J. Linn. Soc. London, Zool. 28 (184):417-433, pl. 37.
- 1910. On the Foraminifera and Ostracoda from soundings (chiefly deepwater) collected round Funafuti by H.M.S. *Penguin*. J. Linn. Soc. London, Zool. 30(202):388-444, pls. 54-57.
- DOEGLAS, D. L. 1931. Ostracoden van Noord-Ost. Borneo. Wetensch. Meded. Dienst minj-bouw Nederl. Indië 17:26-54, pls. 4-5.
- EGGER, J. G. 1901. Ostracoden aus Meeresgrund-Problem gelothet von 1874-1876 von S.M.S. *Gazelle* Abh. Math.-Phys. Cl. Koninkl. Bayer. Akad. Wiss. 21, pt. 2:413-478, 8 pls.
- FISCHER, S. 1855. Beiträge zur Kenntniss der Ostracoden. Bayer. Koninkl. Akad. Math.-Phys., Classe 7, pt. 3:637-666, pls. 19-20.
- FYAN, E. C. 1916. Some young-pliocene ostracodes of Timor. Koninkl. Akad. van Wetenschappen, Amsterdam, Proc. Sec. Sci. 18, pt. 2(7):1205-1217, 1 pl.
- GEIGER, M. E. 1962. Planktonic foraminiferal zones in the Upper Tertiary of Taranaki, New Zealand. New Zealand J. Geol. Geophys. 5(2):304-308, figs. 1-2.
- HANAI, T. 1957. Studies on the Ostracoda from Japan. 1. Subfamily Leptocytherinae, new subfamily: J. Fac. Sci., Univ. Tokyo, Sec. 2, 10, pt. 3:431-468.
- 1959. Studies on the ostracods from Japan; historical review with bibliographic index of Japanese Ostracoda. J. Fac. Sci., Univ. Tokyo, Sec. 2, 11, pt. 4:419-439.
- HORNIBROOK, N. DE B. 1952. Tertiary and Recent Marine Ostracoda from New Zealand; Their Origin, Affinities, and Distribution. New Zealand Geol. Surv., Paleontol. Bull. 18, 82 pp., 18 pls.

- Keij, A. J. 1953. Preliminary note on the Recent Ostracoda of the Snellius Expedition. Koninkl. Nederl. Akad. van Wetenschappen, Amsterdam, ser. B, 56, pt. 2:155-168, pls. 1-2.
- 1954. Some Recent Ostracoda of Manila (Philippines). Koninkl. Nederl. Akad. van Wetenschappen, Amsterdam, ser. B., 57, pt. 3:351-363.
- 1957. Eocene and Oligocene Ostracoda of Belgium. Inst. Roy. Sci. Nat. Belgique, Mém. 136. 210 pp., 23 pls.
- 1964. Neogene to Recent species of *Cytherelloidea* (Ostracoda) from northwestern Borneo. Micropaleontology 10(4):415-430, pls. 1-3.
- KINGMA, J. T. 1948. Contributions to the Knowledge of the Younge-Cenozoic Ostracoda from the Malayan Region. Diss. Univ. Utrecht. Kemink Printers, Utrecht. 119 pp., 11 pls.
- KORNICKER, L. S. 1961. Ecology and taxonomy of Recent Bairdiinae (Ostracoda). Micropaleontology 7(1):55-70, 1 pl.
- LATREILLE, P. A. 1802. (An. X. de R.) Histoire Naturelle, générale et particulière des crustacés et des insectes. Ouvrage faisant suite à l'Histoire Naturelle, générale et particulière, composée par Leclerc de Buffon, et redigée par C. S. Sonnini, membre de plusieurs sociétés savantes. Paris. Vol. 3, p. 17; vol. 4, pp. 232-254.
- LE ROY, L. W. 1939. Some small Foraminifera, Ostracoda, and otoliths from the Neogene of the Rokan-Tapanoei area, Central Sumatra. Natuurk. Tijds. Nederl.-Indië, pt. 6, 99: 215-296.
- 1941. The ostracode genus *Cytherelloidea* from the Tertiary of Netherlands East Indies: J. Paleontol. 15(6):612-621, pl. 83.
- 1943. Pleistocene and Pliocene Ostracoda of the coastal region of Southern California: J. Paleontol. 17(4):354-373, pls. 58-62.
- MCCOY, F. 1844. Synopsis of the Characters of the Carboniferous Fossils of Ireland (Crustacea). Dublin Univ. Press, Dublin. Pp. 159-168.
- MENARD, W. H., E. C. ALLISON, AND J. W. DURHAM. 1962. A drowned Miocene terrace in the Hawaiian Islands. Science 138 (3543): 896-897.
- MOORE, R. C., ed. 1961. Treatise on invertebrate paleontology; pt. Q. Arthropoda 3. Geol. Soc. America and Univ. Kansas Press. 442 pp.
- MORKHOVEN, F. P. C. M. VAN. 1963. Post Paleozoic Ostracoda, Their Morphology, Taxonomy and Economic Use, vol. 1. Elsevier Co., Amsterdam (1962-). 204 pp.
- MÜLLER, G. W. 1894. Die Ostracoden des Golfes von Neapel und der angrenzenden Meeres-Abschnitte. Fauna u. flora des Golfes von Neapel, Zool. Stat., monogr. 21. Berlin. 404 pp., 40 pls.
- NEVIANI, A. 1928. Ostracodi fossili d'Italia; I Vallebajia (Calabrian). Mem. Pont. Accad. Sci., ser. 2, 11:1-120, 2 pls.
- NORMAN, A. M. 1962. Contributions to British carcinology; 2, On species of Ostracoda new to Great Britain. Ann. Mag. Nat. Hist. 9(3):43-52, pls. 2-3.
- PURI, H. S. 1955. *Hermanites*, new name for *Hermania* Puri, 1954. J. Paleontol. 29(3): 558.
- 1957. Stratigraphy and zonation of the Ocala Group. Florida Geol. Surv., Geol. Bull. 38, 248 pp.
- 1960. Recent Ostracoda from the west coast of Florida. Trans. Gulf Coast Assoc. Geol. Soc. 10:107-149.
- SARS, G. O. 1866. Oversigt af Norges marine ostracoder. Förhandl., Vidensk. Selskab. Christiania (1865) 7:1-130.
- 1888. Nye Bidrag til Kundskaben om Middelhavets Invertebrat fauna; 4, Ostracoda Mediterranea. Archiv. Math. Naturvidenskab, Kristiania 12:173-324, pls. 1-20.
- 1922-28. An account of the Crustacea of Norway. Bergen Mus., Norway 9:1-277.
- SCOTT, A. 1905. Report on the Ostracoda collected by Herdman, at Ceylon in 1902. Ceylon Pearl Oyster Fisheries Mar. Biol. Suppl. Rept. 22:365-382, 2 pls.
- SOHN, I. G. 1960. Paleozoic species of *Bairdia* and related genera. U. S. Geol. Surv. Prof. Paper 330-A, 105 pp., pls. 1-6.
- STEARNS, H. T. 1946. Geology of the Hawaiian Islands. Hawaii Div. Hydrogr., Bull. 8, 106 pp.



- SWAIN, F. M. 1963. Pleistocene Ostracoda from the Gubik Formation, Arctic Coastal Plain, Alaska. *J. Paleontol.* 37(4):798-833, pls. 95-99.
- SYLVESTER-BRADLEY, P. C. 1947. Some ostracod genotypes. *Ann. Mag. Nat. Hist.* (1946), ser. 11, 13(99):192-199.
- 1948. The ostracode genus *Cythereis*. *J. Paleontol.* 22(6):792-797.
- TRIEBEL, E. 1954. *Loxoconchella* n. g. (Crust., Ostr.). *Senckenbergiana Lethaea* 35:17-21, 2 pls.
- TODD, RUTH. 1964. Planktonic Foraminifera from deep-sea cores off Eniwetok Atoll. U. S. Geol. Surv. Prof. Paper 260-CC, pp. 1067-1100, pls. 289-295.
- VEEN, J. E. VAN. 1936. Die Cytheridea der Maastrichter Tuffkreide und des Kunrader Korallenkalkes von Sud Limberg; 2, Die Gattungen *Loxoconcha*, *Monoceratina*, *Paracytheridea*, *Xestoleberis*, *Cytheropteron* und *Cytherura*. *Natuurh. Maandbl. Maastricht* 25(2-9):21-24, 32-36, 42-45, 61-64, 69-71, 82-86, 98-101, 108-113, 131-188, 4 pls.